A HANDBOOK TO COTTON SPINNING

BY

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A HANDBOOK

TO

COTTON SPINNING.

COMPILED FOR THE GENERAL USE OF YOUNG CARDERS, SPINNING OVERLOOKERS, AND ALL STUDENTS OF COTTON SPINNING.

BY J. E. HOLME.

SECOND EDITION, REVISED AND ENLARGED.

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INTRODUCTION.

THE Author, having been an erector and starter of new Cotton Mills in most manufacturing towns in England, America, France, Belgium, Germany, and Switzerland, with a good many years' experience, wishes the reader to bear in mind that he has written this book for the use of young carders and spinning overlookers, and his aim is to make the calculations as simple as possible, and touch on everything briefly and concisely, so that it can be a handy and useful book.

The first thing the reader should do in practice is to see that all the machinery be well balanced and all shafts as true as possible; if the machines are not so, there is a continual shaking and vibrating of the machines, which will soon run them down and add to the work of the engine.

The blowing-room machinery should be kept well oiled, clean, and in proper order, on account of the high speed; the same with the cardroom and spinning machinery. If the rollers are not kept nicely oiled, clean, and in proper order, they will cut the sliver and yarn, and therefore bad work and dissatisfaction will be the result; but by attending to these little but important matters, he does not see much difficulty in working machinery satisfactorily.

J. E. H.

PREFACE.

With new mills and improved machinery in cotton spinning there has been initiated new systems of dispensing information. Technical Schools and Classes, fostered by the Society of Arts, the City and Guilds of London Institute, and it is to be hoped at an early date the local corporate bodies, are taking the place of the old systems of apprenticeship and haphazard education, and preventing the rising generations from growing up to rule of thumb principles, or in ignorance of their surrounding work.

With the spread of elementary education, and also technical education, there has sprung up a demand for literature of a technical character, and this is being supplied by the work of such men as Mr. Holme, the author of this book. Men of great practical experience, or scientific men who have taken for their special study one of the British industries, are thus enabled to place the result of their labours before the thousands of workmen who are anxious for more knowledge on their own occupation and allied industries.

The writer regrets the cause of his having to edit this—the second—edition of the work, the reason being the lamented and early death of Mr. Holme. He hopes that the second edition, which now appears, and has been arranged on similar lines to those laid down by Mr. Holme, will meet with the same appreciation as the first edition. Some important alterations and additions have been made, among others the insertion of illustrations, for which our thanks are due to the eminent machinists, Messrs. Howard and Bullough, of Accrington, who have allowed us to illustrate the book with representations of their excellent productions of spinning machinery; and to Messrs. Taylor, Lang, and Co., of Stalybridge, who have lent us the block for the illustration of their admirable make of mule.

C. P. Brooks.

Stalybridge,
October, 1889.

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CONTENTS.

COTTON SPINNING.

COTTON—THE DIFFERENT VARIETIES AND THEIR CAPABILITIES.

THE cotton spinning and weaving industry of the United Kingdom ranks second only to the agriculture of the country in its importance, both in the number of people employed, the capital invested, and the extent of the commerce engendered by its operations. In this manual it is our province to deal with one of the great divisions of the trade—the branch which includes all the processes for converting the raw material as it arrives in this country into a thread technically called yarn; these processes, which are extensive and somewhat complicated, are all included under the commercial name of cotton spinning. The other branch of the trade, cotton manufacturing, includes a group of processes for the conversion of yarn into cotton cloth.

In this work the raw material is first treated of, and subsequently each machine is succinctly described.

Cotton.—Our chief supplies of cotton are drawn from the United States of North America; next in importance, although far removed in quantity of cotton exported from the first-named, is East India, then Egypt, and lastly Brazil. Cotton is a

fibrous vegetable substance, being the fruit of the cotton plant, a shrub of the *Malvaceæ*, genus *Gossypium*. There are several varieties of this plant, but the development of the raw material is the same in each. The plant attains its full height about June (this being about two months subsequent to sowing), and the bolls or seed pods are found to be ripening about the middle of July. These bolls, about 1in. diameter, are divided by membranous walls into three parts, containing three or four seeds each, covered with the thin transparent cylindrical fibres attached by one end to the seed.

As the fruit approaches maturity these fibres lose their cylindrical form, becoming ribbon-shaped through the collapse of their walls, and at the same time each fibre twists on its axis, thus causing a sufficient pressure on the interior of the boll to burst it at the junction of the compartments in the outer casing.

After being left on the trees for some days, during which time the ripening influences are at work, increasing the convolutions and maturing the fibre—or exposed, perhaps, in the case of unfavourable weather, to the damaging influence of rain, which stains the cotton; intense heat, which renders it brittle; or wind, which fills the boll with sand or leaf—the cotton is picked. It is then passed through a gin, a machine which has for its object the separation of the fibre from the seed. This latter, which in medium-stapled cotton exists in the proportion of 2lb. seed to 1lb. fibre, is used up at the oil mills, while the cotton is

packed in bales of 4cwt. and forwarded to the sea coast for export. The foregoing may be taken as a condensed description of the cultivation of cotton on an American plantation. In Brazil and Egypt the season is about a fortnight later; in India planting generally commences in July, or immediately after the dry season.

The raw fibre is a ribbon-shaped filament with corded edges, twisted with 300 to 800 convolutions to the inch; thus, although to the naked eye appearing quite smooth, under the microscope it has somewhat of a resemblance to the shape of a joiner's auger. The fibres are exceedingly light, a pound being supposed to contain more than 130,000,000 fibres.

Cotton is, of course, vegetable matter principally, about 86 to 90 per cent being cellulose, a woody substance, chemically described as $C_6H_{10}O_5$, or 6 parts carbon, 10 hydrogen, and 5 oxygen. Over 10 per cent of the cotton in its raw state consists of natural moisture; only 6 per cent of this can be driven out at the heat of boiling point of water.

Cotton fibres are covered with a substance called vegetable wax, and which is present to the extent of about $\frac{1}{2}$ per cent.

Varieties of Cotton.—The longest fibre is the Sea Island cotton, grown off the coast of the States, averaging $1\frac{3}{4}$in. in length, and chiefly spun into 150's to 600's yarn, although for experimental purposes 2150's have been produced from it. Egypt gives three varieties—brown, white, and Gallini. The first-named is commonest, and is used for 50's to 150's wefts and 100's twist.

The American States yield a comparatively clean and even-running cotton, the best variety being Orleans, of a mean length of $1\frac{1}{8}$in., used for 30/50's T and 30/70's wefts. Texas, though shorter, is from its strength used for warp yarn, while the numerous varieties classed as uplands or boweds are suitable for weft on account of their usual good colour and cleanliness. The difference between the white 60's and 70's wefts and brown ditto is that the latter is from brown Egyptian cotton.

Brazilian is a very harsh fibre about average length, and used for twists, either alone or mixed with American.

The East Indian varieties are extremely variable in length, and also in relation to the quantity of weak fibres; the properties common to almost the whole being brown colour, and dirty and rough character of the cotton. It is chiefly used in Rossendale, Bury, and Oldham for coarse counts.

Table I.

THE CHARACTERISTICS OF RAW COTTONS.

AMERICAN.

Name of Cotton.	Length of Staple. Max. In.	Min. In.	Mean. In.	Description.	Capabilities.
Sea Islands......	$1\frac{15}{16}$	$1\frac{5}{8}$	$1\frac{3}{4}$	Silky & regular...	Spin up to 600's.*
Florida Sea Islands.........	$1\frac{5}{8}$	$1\frac{1}{4}$	$1\frac{7}{16}$	ditto	Spin up to 200's.
Alabama	$1\frac{3}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	Short and soft ...	Spin up to 60's or 70's weft.
South Carolina .	$1\frac{3}{16}$	1	$1\frac{1}{8}$	ditto	ditto
Texas	1	$\frac{11}{16}$	$\frac{7}{8}$	Strong in staple..	Spin up to 60's weft, makes good 32's twist.
Orleans	$1\frac{1}{4}$	1	$1\frac{1}{8}$	Regular & good...	Spin up to 70's weft, or 50's twist ; is the best of the ordinary American cottons.

BRAZILIAN.

Brazilian	$1\frac{1}{2}$	$\frac{7}{8}$	$1\frac{1}{8}$	Harsh and wiry...	Spin up to 60's or 80's

Includes Ceara, Paraiba, Rio Grande, Maranham ; these are generally mixed with good American for twist yarn.

EGYPTIAN.

Brown	$1\frac{1}{2}$	$1\frac{3}{16}$	$1\frac{5}{16}$	Silky & regular...	Spin up to 150's weft, and 80's to 100's twist.
Gallini	$1\frac{5}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	Like Sea Island...	Spin up to 210's weft.
White	$1\frac{7}{16}$	$1\frac{1}{8}$	$1\frac{1}{4}$	Hard	Spin up to 90's.

POLYNESIAN.

Fiji, Sea Island.	$1\frac{15}{16}$	$1\frac{1}{4}$	$1\frac{3}{4}$	Not regular	Spin up to 100's or 150's.
Greek Islands...	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	ditto	Spin up to 70's or 80's.

PERUVIAN.

Peruvian	$1\frac{5}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	Tree cotton	Spin up to 50's or 60's; very little used.

WEST INDIAN.

West Indian ...	$1\frac{7}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	Good in staple ...	Spin up to 50's or 60's; irregular.

EAST INDIAN.

Hingunghet ...	$1\frac{7}{16}$	1	$1\frac{1}{4}$	Not reg. in staple.	Indian cotton is used alone for 12's to 22's yarn, and mixed with short American for 20's to 28's yarn.
Bengal	$1\frac{1}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	ditto	
Broach	$1\frac{1}{8}$	$\frac{7}{8}$	1	ditto	
Dhollerah	$1\frac{1}{8}$	$\frac{3}{4}$	$\frac{15}{16}$	ditto	

AFRICAN.

African	$1\frac{7}{16}$	$1\frac{1}{8}$	$\frac{13}{16}$	Not good in staple.	Spin up to 26's or 28's; very little used.

* It is quite possible to spin up to 600's, and indeed it is regularly done ; for experimental purposes 2150's have been spun.

Table II.

LENGTH AND DIAMETER OF COTTON FIBRES.

Place of Growth.	Description of Cotton.	Length of Staple.				Diameter of Fibre.			
		Inches and Decimals.			Fractions.	Inches and Decimals.			Fractions.
		Longest.	Shortest.	Average.	Average.	Thickest.	Thinnest.	Average.	Average.
United States..............	New Orleans..............	1·16	·88	1·02	$1\frac{1}{50}$	·00097	·00058	·00077	$\frac{1}{1290}$
Ditto	Sea Islands	1·80	1·41	1 61	$1\frac{6}{10}$	·00082	·00046	·00064	$\frac{1}{1562}$
South America	Brazil	1 31	1·03	1·17	$1\frac{17}{100}$	·00096	·00062	·00079	$\frac{1}{1265}$
Egypt	Brown Egyptian	1·52	1·30	1·41	$1\frac{41}{100}$	·00072	·00059	·00065	$\frac{1}{1526}$
India	Indigenous or native ...	1·02	·77	·89	$\frac{89}{100}$	·00104	·00065	·00084	$\frac{1}{1185}$
	American Seed...........	1 21	·95	1·08	$1\frac{2}{25}$	·001	·00065	·00082	$\frac{1}{1212}$
	Sea Island Seed	1·65	1·36	1·50	$1\frac{1}{2}$	·00086	0006	·00073	$\frac{1}{1369}$

The above table is derived from one in Evan Leigh's admirable work on Cotton Spinning.

The principal market for raw cotton is Liverpool; the Continental markets are Havre and Bremen. The cotton is purchased in the large interior towns of cotton-growing countries by dealers from the planters, and then sold to the exporters at the seaports. In Liverpool, it passes through the buying and selling brokers to the spinners.

Grades of Cotton.—Cotton is graded in different classes, depending chiefly upon its cleanliness.

The **American** cotton grades are :—

Good ordinary.
Low middling.
Middling.
Good middling.
Middling fair.

Brazilian:—

Middling fair.
Fair.
Good fair.

Egyptian :—

Fair.
Good fair.
Good.

Indian :—

Fair.
Good fair.
Good.
Fine.

The first-mentioned are the poorest in each case.

COTTON MIXING.

It is as well to make the mixing as large as conveniently possible. Cotton, when bought in large quantities, varies in length and strength of staple, also in its colour, and in the amount of sand, leaf, and seeds, &c.; so there must be the greatest care in this department. The best way to make the mixing or stack is to open as many bales as room will allow, and to take different samples from every bale, as the cotton often varies very much, even in one bale, and mix accordingly, taking care that all the different layers are about the same thickness—that is, one or two bales to a layer, according to size of mixing required. When the stack is complete, the best way to take the cotton from it is to have a short pronged iron rake, and rake it right from the breast from the top to the bottom; for if it is pulled off in armfuls the yarn will be uneven, and not of the required strength. If the yarn is not up to the required strength and quality, it is an easy matter to add another layer or so of a better quality of cotton, but it must be about the same length of staple. After it is once got right, it is a good plan to keep a few cops as a standard sample. Mixing can also be done in the laps; *e.g.*, two good and two inferior in quality put through the lap machine together, or otherwise, according to the counts required to be spun. The best attention should be given to the mixing, as, if badly mixed, it cannot be rectified afterwards, for

long and short staple cotton will not work well together. It is as well to test the amount of sand, &c., that is in the different bales.

To Find Percentage of Loss.—Suppose we take fifty pounds of cotton from a bale, and pass it through the blowing machinery and the card, and it loses five pounds in weight, what will be the percentage of loss?

Example—

Cotton taken.		*Loss.*		*Cent.*
50	:	5	::	100
		100		

50)500(10 per cent.
500

Ans.—10 per cent loss.

Or again, suppose that ninety pounds be taken, and the loss found to be eight pounds, what will be the percentage of loss?

Cotton taken.		*Loss.*		*Cent.*
90	:	8	::	100
		100		

90)800(8·88 per cent.
720

800
720

80

Ans.—8·88 per cent, or nearly 9 per cent loss.

SPINNING PROCESSES.

It is now necessary to take each process separately and describe shortly the machines, giving the necessary calculations in each case.

The machinery described is such as is adapted to the spinning of medium counts—*i.e.*, from 24's to 70's. The bulk of the spinning machinery of the kingdom is engaged on these numbers, which are generally called Oldham counts. The coarse numbers are generally spun in Rochdale and some Oldham mills. The medium counts are spun in Oldham, Mossley, Ashton and district, Glasgow, Darwen, Blackburn, Preston, and most spinning districts; counts from 80's to 150's, medium fine, are spun chiefly in Bolton, Farnworth, Paisley, Stockport, and Stalybridge. The finest counts are spun in Reddish and Manchester.

In 1886, according to the estimate of Messrs. Ellison, of Liverpool, the number of spinning spindles in various parts of the world was as follows:—

Great Britain	42,700,000
Continent	22,900,000
United States..................	13,350,000
East Indies	2,100,000
	81,050,000

Summary of Processes.*—The spinning department, to describe it briefly, consists of:—

1. *Mixing* the cotton in stacks to secure thorough blending of various qualities, and elimination of the unevenness present in different bales or parts of one bale. Then commence processes for cleansing, viz.:—
2. *Opening* or passing the matted pieces of the bales through a series of armed beaters, having the functions of both separating the material into small flakes and removing the heavier impurities contained in it, such as sand and seeds.
3. *Scutching.*—In this process a wing beater, revolving at a speed of 11/1500 revolutions per minute, removes the remainder of the heavy dirt, delivering the material in the form of a lap or roll of cotton. This process is repeated.
4. *Carding.*—Here, by means of revolving cylinders covered with fine wire teeth, and combing the cotton against other cylinders or plates similarly covered, the light impurities—leaf, dust, short and weak fibres—are extracted, and the lap attenuated into a thin sliver, in which the fibres are laid in such a position as to be easily drawn parallel at the drawing process. These four kinds of cleaning machinery remove impurities and other matter foreign to the nature of cotton to

*This Summary is from a book by the Editor—Mr. C. P. Brooks' work on "COTTON MANUFACTURING and the Preparatory Processes for both Plain and Fancy Weaving."

the extent of about 10 per cent, taking middling American cotton.

5. *Combing.*—The long fibres are here separated from the short, thus enabling a portion of the cotton to be used for spinning finer yarns than the bulk would spin. It is only in the mills spinning yarns above, say 80's, that this process is found; in ordinary, the custom is to go direct from carding to
6. *Drawing.*—A simple process, repeated for yarn up to 30's, used three times up to 60's, and four processes are used above this. The machine has for its object the levelling of the slivers, six of which are placed together and drawn six times the original length. When this has been repeated once or twice, the sliver becomes very even and silky in consequence of all the fibres having had the curl taken out and been laid parallel to each other.
7. *Slubbing;* 8. *Intermediate;* and 9. *Roving.* These frames are all constructed on one principle, and have for their object the gradual diminution of the thickness of the sliver, which at these processes is attenuated so much as to require twisting to keep it from breaking at the succeeding process. An additional jack roving frame is used at mills making over 100's yarn.
10. *Spinning* completes the object of all the former machines—*i.e.*, to produce a level clean thread, free from unevenness in every respect. The machines used for this are either mules, ring frames, or throstle frames.

THE OPENER.

THE object of this machine, as its name indicates, is to separate the matted masses of fibres caused by the compression of the cotton bale, and also to free the cotton from the heavier kinds of impurities which it contains. There are three classes of openers. The double vertical opener, or Crighton, is designed to give a greater amount of opening to the raw material in transit through the machine. It consists of two vertical beaters, and in the working of the lower numbers it performs its work well and satisfactorily; but in the finer numbers, where long-stapled cotton is used, there is a danger of injuring the fibre, for in fine numbers much opening is not required, as too much beating is worse than too little. The opener I intend describing is the one with the porcupine cylinder, which consists of one, two, or even three cylinders, two cages, two lattice creepers—one to take the cotton in and the other to take it out—together with feed rollers, fan, dust chamber, and sides with pulleys, &c. The first cylinder has about twelve rows of teeth, the second four rows. A third and very good form of opener is the scutcher opener, or exhaust opener, shown in fig. 1, which contains a horizontal conical beater, of eight double arms or knives, from 18in. to 28in. in length, and one or two ordinary lap machine beaters. The cotton is fed into this machine through a tube from the mixing room, and, as shown in fig. 1, exudes as a lap.

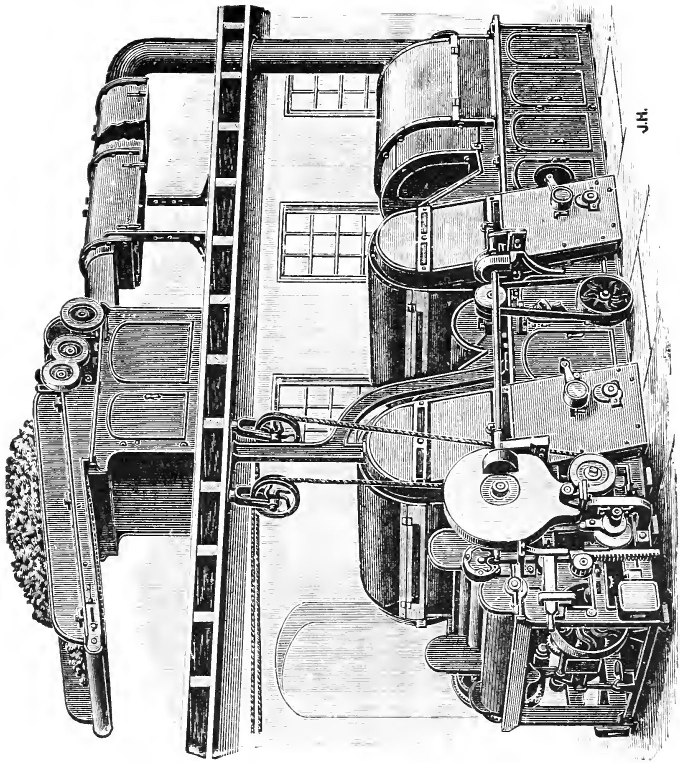

Fig. 1.—Howard and Bullough's Opener and Feeder.

To calculate the Speed of the Opener and other machines.

Rule.—*Multiply the revolutions of the driving shaft with the diameters of the driving pulleys and wheels together for a dividend, and the driven pulley and wheels multiplied together for a divisor. The quotient will be the answer.*

Example—

Revolutions of main driving shaft ...	145 revolutions per minute.
Pulley on " " ...	25in. diameter.
Driven pulley on countershaft	12in. "
Driving " "	38in. "
Pulley on end of cylinder shaft	12in. ".

Driven.		*Driver.*
Driven pulley on countershaft	12	145 Speed of main driving shaft.
Driven pulley on cylinder shaft	12	25 Dia. " pulley.
	144	

```
 145
  25
 ----
 725
290
 ----
3625
  38 Countershaft driving pulley
 -----
 29000
10875
 -----
144)137750(956·5 revolutions of porcupine cylinder.
    1296
    ----
     815
     720
     ---
      950
      864
      ---
       860
       720
       ---
       140
```

or, $\dfrac{145 \times 25 \times 38}{12 \times 12} = 956\frac{1}{2}$ revolutions of cylinder.

To find the Speed of Fan.

Rule.—*Take the speed of countershaft multiplied by the diameter of pulley on it for a dividend, and for a divisor the diameter of fan pulley, and quotient will be the revolutions of the fan. Firstly, find the speed of countershaft, having the speed of main shaft and driving pulley.*

Example—

```
Speed of main shaft 145 × diameter of pulley 25 is 3625.
Pulley on countershaft 12)3625(302·08 speed of countershaft.
                          36
                          ——
                           25
                           24
                           ——
                            100
                             96
                            ———
                              4
                            ———
                         302·08
                             18  countershaft driving pulley.
                         ——————
                         241664
                         30208
                         ——————
Diameter of fan pulley 6·00)543·744(906·24
                         5400
                         ————
                           3744
                           3600
                           ————
                            1440
                            1200
                            ————
                             2400
                             2400
```

Ans.—906·24 revolutions of fan.

The points which require attention in opening are: To pass the cotton through lightly, and not

overload the machines; to be careful to let as little cotton go with the droppings as possible; and to have the drafts so arranged as not to let the cotton pass the same beater twice.

An opener is capable of passing about 30,000lb. per week.

SCUTCHING.

THE BREAKER-LAP MACHINE, OR FIRST SCUTCHER.

This machine is the first where attenuation of the cotton takes place—that is, the drawing out of the cotton from a shorter to a longer length, the cotton being formed into what is called "a lap." The greatest care should be given to the feeding of this machine. All the cotton spread on the lattice creeper should be of a given weight to a given distance—say thirty to forty ounces to one yard. The machine should not be overloaded with cotton, as it can only do a certain amount to advantage. But where mechanically fed and automatically regulated at the feed rollers, weighing can be dispensed with, except that every lap made should be weighed. This should be done in all the lap machines to insure good and even work afterwards. The chief object is to keep the lap uniform in thickness and the full width.

Scutchers are either hand-fed, or where a lap has been formed at the opener they are fed by placing three or four laps on the lattice.

The machine, which is shown in fig. 2, includes a feeding lattice, feed rollers, or, what is better, one feed roller and Lord's regulating bars, a two or three bladed horizontal beater, revolving, for two blades, about 1,100 to 1,400 per minute; the lesser speed for finer work. There are also dust cages to carry off the lighter impurities, and a lap-forming arrangement. The dirt removed by the beaters, in the form of droppings, consists of seed,

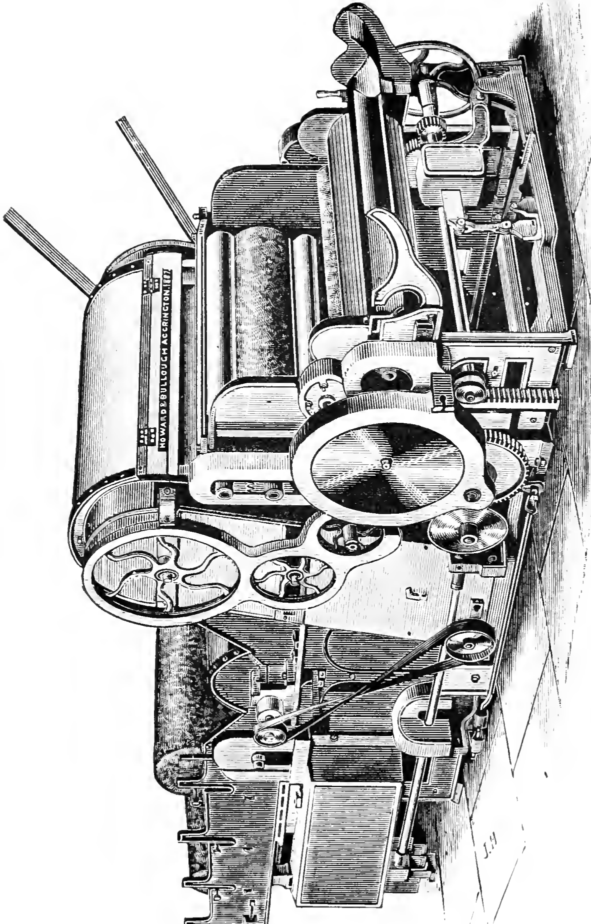

Fig. 2.—Scutcher and Lap Machine.

sand, husks, and lumps. One finished lap is about equal in weight to any one of the feed-laps, so that with three laps on the feed there is a draft in the machine of three, which attenuates the laps as the cotton passes through.

It is important that the finished laps be got as level and similar in weight as possible, and to attain this the regulating motion should be kept clean and in good order; also lapping, plucking, and licking should be avoided. The dirt should be removed five times a day. The noses of the levers should not be too pointed. The remarks applied to opening also refer to scutching. The capacity of the scutcher is about 10,000lb. per week.

The speed of beater is regulated according to the number of blades in beater, and the quality of cotton required to work. The fan is also regulated, to some extent, in the same way.

Speed of a three-bladed beater from 900 to 1,200 revolutions. Speed of a fan from 1,000 to 1,300 revolutions.

The speed of the beaters and fan will vary according to the tightness of belt, and a close watch should be kept on the belt and on the regulating cones, as a change in the weather affects all belts to some extent.

To find the Speed of Beater, use former rule.

Example—

Line shaft	150 revolutions.
Pulley on ditto	24in. driver.
Pulley on counter shaft	10in. driven.
,, ,, ,, driving beater.	30in. driver.
,, beater	10in. driven.
,, ,, shaft to drive fan......	7in. driver.
,, fan shaft	5in. driven.

Driven counter pulley, 10in. 150 speed of line shaft.
,, beater end ,, 10in. 24in. pulley on shaft.

```
                100       600
                         300
                         ————
                         3600
                          30in. dia. pulley driving beater.
                         ————
            100)108000(1080 revolutions of beater.
                 100
                 ———
                   800
                   800
```

Or thus: $\dfrac{150 \times 24 \times 30}{10 \times 10} = 1080$ rev. of beater.

To find the Speed of Fan.

Rule.—*Multiply the revolutions of the beater by the diameter of the pulley on it, and divide the quotient by the diameter of the fan pulley.*

Same dimensions as given in last example.

Example— 1080 revolutions of beater shaft.
7in. pulley on beater shaft.

```
Dia. of fan pulley 5in.)7560(1512 revolutions of fan.
                        5
                        —
                        25
                        25
                        —
                          6
                          5
                         —
                          10
                          10
```

Or thus: $\dfrac{1080 \times 7}{5} = 1512$ revolutions of fan.

To find the Draft of the Opener and Lap Machine.

Rule.—*Multiply all the driven wheels and the delivery rollers together for a dividend, and the driving wheels and the feed roller for a divisor; then the quotient will be the draft.*

Example—

Front roller	6in.		driven.
Feed ,,	$2\frac{1}{2}$in.		driver.
Bevel wheel on end of callender,	60 teeth		,,
Top of side shaft	30	,,	driven.
Bottom of side shaft	25	,,	driver.
Driving a wheel of	40	,,	driven.
On boss of which is a wheel	12	,,	driver.
Feed roller wheel	20	,,	driven.

60	
$2\frac{1}{2}$	
120	
30	
150	30
25	6
750	180
300	40
3750	7200
12	20
45000	)144000(3·2
	135000
	90000
	90000

Or thus :

$$\frac{30 \times 6 \times 40 \times 20}{60 \times 2\frac{1}{2} \times 25 \times 12} = 3{\cdot}2 \text{ draught.}$$

Ans.—3·2 draft of lap machine.

FINISHER SCUTCHER, OR LAP MACHINE.

This machine is made for the purpose of cleaning and also obtaining a greater uniformity in the weight of a given length of cotton or lap. This is done by the feeding-in together of a number of laps from the previous machine, usually three or four laps, as are required. In cases where there are two or three varieties of cotton used, managers sometimes use this machine for blending them together—*e.g.*, American and Egyptian, which combine well together. When the two different cottons are put on to the lattice, and, passing through the feed rollers to the beaters, come under the action of the beaters, the cotton is broken up into light flakes and mixed.

Fig. 2 shows the scutcher or lap machine. I do not intend to give any calculations for this machine as to the draft, as it can be got just in the same way as in the breaker scutcher or lap machine, but I will give the places where the draft takes place in the machine, as it may be of some help to the reader.

Draft between iron rollers and lap rollers.
,, ,, creeper and iron rollers.
,, ,, feed rollers and creepers.
,, ,, feed cloth and feed rollers.

Should the reader have any doubts as to his having the right draft in the machine, if he will put one yard on the feed cloth, and when through should it measure three yards, it will be three of a draft. Rule: spread thirty ounces of cotton to

three feet on feeder, and measure from off the lap six feet from the middle portion; if this six feet weighs twenty ounces, the machine has a draft of three.

Example—

3 feet spread on feeder weighing 30 ounces.
20 ounces for 6 feet delivered, 6 feet measured.

60	60)180(3 of a draft.
	180

This is not really the correct draft, as there is a loss of the cotton in passing through, but it is near enough.

If you require to find whether the lap machine is doing its work in a satisfactory manner as regards a uniform weight throughout the lap, cut the lap into six feet lengths, and weigh the different lengths and see if they vary to any great amount; if so, the machine is not evening and regulating properly, which may arise from a slack cone belt; or under the piano motion there may be some dirt and cotton wedged in the spaces which will not allow the levers to move, so that it is impossible for them to work satisfactorily. There are various other causes, such as not running up to required speed of beater and fan, &c. The remarks on the working of the machine given in connection with the breaker scutcher apply to the finisher scutcher.

To find the Length of Lap.

Rule.—*Multiply the weight of the lap, reduced to ounces, by three yards for a dividend, and divide by the weight of three yards, reduced to ounces, for a divisor, then the quotient will be the length required.*

Example—

Weight of 3yds. weighed.

Lb.	*oz.*	*Lb.*
2	12	41 weight of lap.
16		16 oz. in one pound.
12		246
2		41
32		656 ounces.
12		3 yards.
44 ounces.		44)1968(44·2·2 = 44yds. 2ft. 2in.

176

208
176

32
3 feet.

44)96(2 feet.
88

8
12 inches in one foot.

44)96(2 inches.
88

8

How to find the bevel change pinion on horizontal shaft that gears in bevel on cross shaft, when changing from one weight of lap to another, without altering the length of lap.

Rule.—*Multiply the present pinion by present weight of lap, and divide by proposed weight of lap.*

Example.—Suppose the machine be making a lap of forty pounds in weight with a twenty bevel change pinion on horizontal shaft, what pinion is required to make a lap of thirty-five pounds weight ?

35lb. : 40lb. :: 20 change pinion.

```
               40
               20
              ----
          35)800(23 change pinion required.
              70
              ----
              100
              105
```

Ans.—The nearest change pinion is 23.

To get the size of the pulley on the cross shaft (when the evening motion is driven by a belt), when changing from one weight of a lap to another, without altering the length of the lap.

Rule.—*Multiply the weight of proposed lap by present pulley, and divide by present weight of lap.*

Example.—Supposing the machine be making a lap of forty pounds in weight with a sixteen inch pulley on cross shaft, what pulley is required to make a lap of thirty-five pounds in weight?

40lb. : 35lb. :: 16 inches.

```
               16
              ----
              210
              35
              ----
          40)560(14in. pulley required.
              40
              ----
              160
              160
```

The only other calculation required in connection with scutching refers to the hank of the lap, and before this can be explained some remarks must be made on the counts or numbers.

COUNTS, NUMBERS, OR HANKS OF COTTON.

From the earliest stage of the cotton industry it has been found necessary to have some method of indicating the thickness of cotton threads, and there has gradually been built up a table indicating this by weight, a system which seems to be common to the whole of the British cotton trade. 840 yards is taken as a hank, and the number of hanks contained in a pound avoirdupois of 7,000 grains is known variously as the counts, grist, hank, or numbers of cotton yarn. The thinner the thread the higher it is numbered. The numbers or counts signify the number of times that the yarn is finer than 1's.

The complete **Table (III.) of Measurement** is—

$1\frac{1}{2}$ yards	= 1 thread or circumference of a wrap reel.		
120 „	= 80 threads	= 1 lea.	
840 „	= 560 threads	= 7 leas	= 1 HANK.

The Table of Weights is a peculiar one, being a pound avoirdupois divided into the troy weight denominations of pennyweights and ounces.

Table IV.

24 grains	= 1dwt.		
$437\frac{1}{2}$ „	= $18\frac{11}{48}$dwt	= 1oz.	
7000 „	= $291\frac{2}{3}$dwt.	= 16oz.	= 1lb.

The first line only of the table is used.

The system just described applies both to twist and weft.

Wrapping Yarn.—The practical way of testing the counts of yarn is to wind on a wrap reel 120 yards of yarn and weigh this, dividing its weight in grains into 1,000. Thus the thinner a thread is the less it will weigh, and, therefore, a higher count is got by dividing this smaller weight in grains into the given number.

A short explanation is necessary as to the manner in which we get at the number 1,000.

1's yarn contains 1 hank in 1lb.,
therefore it contains 840 yards in 7,000 grains.
or one-seventh of this, 120 ,, in 1,000 ,,

As 840 yards would be too much to wrap, we take one-seventh of the length and also one-seventh of the corresponding weight as a standard.

10's yarn is ten times as fine as 1's, and 120 yards of it weigh 100 grains.

$1000 \div 100 = 10$'s counts.

We should only get the same result if we took 840 yards, which would weigh 700 grains divided into the weight of 840 yards of 1's—*i.e.*, 7000 grains, we get $7000 \div 700 =$ ten times as fine as 1's, or 10's counts.

Should 120 yards of yarn be wrapped and found to weigh 25 grains, then $1000 \div 25 = 40$'s. More than one cop might be taken, and the leas weighed together. Suppose 4 cops are wrapped, 1 lea or 120 yards off each, and found to weigh 3 dwt. and 8 grains, four times 1000 must be taken as the dividend—that is, 4000.

3 dwt. 8 grains = 80)4000(50's counts
4000

Rule.—*To find the counts, wrap* 120 *yards, weigh it, and divide the weight in grains into* 1000, *and if more leas are taken, for as many leas as you wrap take as many* 1000's *for a dividend; then divide by the weight of the leas wrapped.*

Example.—Suppose 2 leas weigh 41 grains, what are the counts?

```
Grains 41)2000(48·8 counts nearly.
          164
          ———
           360
           328
           ———
            320
            328
```

Example.—Suppose 3 leas weigh 50 grains, what are the counts?

```
Grains 50)3000(60 counts.
          300
```

Example.—Suppose 1 lea weighs 50 grains, what are the counts?

```
50)1000(20 counts.
   100
```

To find a constant number for a dividend for a number of yards.

Rule.—*Take* 12 *for a divisor, and divide as many hundreds as you take yards.*

Example.—Take 31 yards and multiply by 100, and divide by 12 the divisor.

```
          Yards.
Divisor 12)3100(258·3 constant number for 31 yards.
           24
           ——
            70
            60
            ——
            100
             96
            ———
              40
              36
              ——
               4
```

Then if 31 yards be wrapped, divide their weight in grains into 258·3, and you get the counts.

Table V.

400	yards	or	4	leas	=	4000	grains	dividend
240	,,		2	,,	=	2000	,,	,,
120	,,		1	,,	=	1000	,,	,,
60	,,		$\frac{1}{2}$	,,	=	500	,,	,,
40	,,		$\frac{1}{3}$	,,	=	333·3	,,	,,
30	,,		$\frac{1}{4}$	,,	=	250	,,	,,
20	,,		$\frac{1}{6}$	,,	=	166·6	,,	,,
15	,,		$\frac{1}{8}$	,,	=	125	,,	,,
10	,,		$\frac{1}{12}$	,,	=	83·3	,,	,,
8	,,		$\frac{1}{15}$	,,	=	66·6	,,	,,
6	,,		$\frac{1}{20}$	,,	=	50	,,	,,
5	,,		$\frac{1}{24}$	,,	=	41·66	,,	,,
4	,,		$\frac{1}{30}$	,,	=	33·3	,,	,,
3	,,		$\frac{1}{40}$	,,	=	25	,,	,,
2	,,		$\frac{1}{60}$	,,	=	16·6	,,	,,
1	,,		$\frac{1}{120}$	,,	=	8·3	,,	,

Yarn Table.—VI.

For weighing 120 yards, or one lea, by pennyweights and grains.

Hanks.		Dwts.		Grains.	Hanks.		Dwts.		Grains.	Hanks.		Dwts.		Grains.
1	...	41	,,	16	35	...	1	,,	4·75	69	...	0	,,	14·49
2	...	20	,,	20	36	...	1	,,	3·77	70	...	0	,,	14·28
3	...	13	,,	21·33	37	...	1	,,	3·02	71	...	0	,,	14·08
4	...	10	,,	10	38	...	1	,,	2·26	72	...	0	,,	13·88
5	...	8	,,	8	39	...	1	,,	1·63	73	...	0	,,	13·69
6	..	6	,,	22·66	40	...	1	,,	1	74	...	0	,,	13·51
7	...	5	,,	26·88	41	...	1	,,	·39	75	...	0	,,	13·13
8	...	5	,,	5	42	...	0	,,	23·80	76	...	0	,,	13·15
9	...	4	,,	15·11	43	...	0	,,	23·25	77	...	0	,,	12·98
10	...	4	,,	4	44	...	0	,,	22·72	78	...	0	,,	12·82
11	...	3	,,	18·90	45	...	0	,,	32·22	79	...	0	,,	12·65
12	...	3	,,	11·33	46	...	0	,,	21·73	80	...	0	,,	12·50
13	...	3	,,	4·72	47	...	0	,,	21·27	81	...	0	,,	12·34
14	...	2	,,	23·42	48	...	0	,,	20·83	82	...	0	,,	12·19
15	...	2	,,	18·66	49	...	0	,,	20·40	83	...	0	,,	12·04
16	..	2	,,	14·50	50	...	0	,,	20	84	...	0	,,	11·90
17	...	2	,,	10·82	51	...	0	,,	19·60	85	...	0	,,	11·76
18	...	2	,,	7·55	52	..	0	,,	19·23	86	...	0	,,	11·62
19	...	2	,,	4·63	53	...	0	,,	18·86	87	...	0	,,	11·49
20	...	2	,,	2	54	...	0	,,	18·51	88	...	0	,,	11·36
21	...	1	,,	23·61	55	...	0	,,	18·18	89	...	0	,,	11·23
22	...	1	,,	20·45	56	...	0	,,	17·85	90	...	0	,,	11·11
23	..	1	,,	19·47	57	...	0	,,	17·54	91	...	0	,,	10·90
24	...	1	,,	17·66	58	...	0	,,	17·24	92	...	0	,,	10·86
25	...	1	,,	16	59	...	0	,,	16·94	93	...	0	,,	10·75
26	...	1	,,	14·46	60	...	0	,,	16·66	94	...	0	,,	10·63
27	...	1	,,	13·03	61	...	0	,,	16·39	95	...	0	,,	10·52
28	...	1	,,	11·71	62	...	0	,,	16·12	96	...	0	,,	10 41
29	...	1	,,	10·42	63	...	0	,,	15·87	97	...	0	,,	10·30
30	...	1	,,	9·33	64	...	0	,,	15·62	98	...	0	,,	10·20
31	...	1	,,	8 25	65	...	0	,,	15·38	99	...	0	,,	10·10
32	...	1	,,	7·25	66	...	0	,,	15·15	100	...	0	,,	10
33	...	1	,,	6·30	67	...	0	,,	14·92					
34	...	1	,,	5·41	68	...	0	,,	14·70					

Wrap Table.—VII.

Carding, Drawing, Slubbing, and Roving.

24 grains 1 pennyweight; 18 pennyweights $5\frac{1}{2}$ grains 1 ounce; 16 ounces 1 pound.

For weighing 30 yards, or one-fourth of a lea.

Hanks.	Dwts.	Grains.	Hanks.	Dwts.	Grains.	Hanks.	Dwts.	Grains.
·5	20	20	2·9	3	14·2	6	1	17·6
·55	18	22·5	3	3	11·3	6·25	1	16
·6	17	8·4	3·05	3	9·9	6·5	1	14·4
·7	14	21	3·1	3	8·6	6·75	1	13
·8	13	·3	3·2	3	6·1	7	1	11·7
·9	11	13·8	3·3	3	3·7	7·25	1	10·4
·95	10	22·9	3·4	3	1·5	7·5	1	9·3
1	10	10	3·5	2	23·4	7·75	1	8·2
1·1	9	11·2	3·6	2	21·4	8	1	7·2
1·2	8	16·3	3·7	2	19·5	8·25	1	6·3
1·3	8	·3	3·8	2	17·7	8·5	1	5·4
1·4	7	10·5	3·9	2	16·1	8·75	1	4·5
1·5	6	22·6	4	2	14·5	9	1	3·7
1·6	6	12·2	4·1	2	12·9	9·25	1	3
1·7	6	3	4·2	2	11·5	9·5	1	2·3
1·8	5	18·8	4·3	2	10·1	9·75	1	1·6
1·9	5	11·5	4·4	2	8·8	10	1	1
2	5	5	4·5	2	7·5	10·25	1	·39
2·1	4	23	4·6	2	6·3	10·5	0	23·81
2·2	4	17·6	4·7	2	5·2	10·75	0	23·26
2·3	4	12·6	4·8	2	4·1	11	0	22·72
2·4	4	8·1	4·9	2	3	11·25	0	22·22
2·5	4	4	5	2	2	11·5	0	21·73
2·6	4	·1	5·25	1	23·6	11·75	0	21·27
2·7	3	20·6	5·5	1	21·4	12	0	20·83
2·8	3	17·2	5·75	1	19·5			

French Yarn Table.

Rule.—*Divide the number of metres reeled by twice the weight in grammes.*

1000	metres	weighing	500	grammes	is	No. 1.
1000	,,	,,	250	,,	,,	No. 2.
1000	,,	,,	50	,,	,,	No. 10.
1000	,,	,,	25	,,	,,	No. 20.
1000	,,	,,	20	,,	,,	No. 25.
1000	,,	,,	15	,,	,,	No. 33·33.
1000	,,	,,	10	,,	,,	No. 50.
1000	,,	,,	5	,,	,,	No. 100.

Conversion of French and English Counts.

In order to convert French into English, multiply by 1·18.
,, ,, English into French, divide by 1·18.

Having the lengths and counts given, to find the weight :—

Rule.—*Divide the length by 840 and by the counts.*

Example.—9240 yards of 44's weft = 9240 yards ÷ 840 = 11 hanks. In the given counts 44 hanks weigh 1lb. ; then 11 hanks weigh $\frac{11}{44}$, or $\frac{1}{4}$ of a lb.

Having the weight and counts given, to find the length :—

Rule.—*Multiply the weight in pounds by 840 and by the counts.*

Example.—79lb. of 17's yarn are required for a warp. What is the total length ?

$$79 \times 17 \times 840$$

$$\begin{array}{r} 79 \\ 17 \\ \hline 553 \\ 79 \\ \hline 1343 \\ 840 \\ \hline 53720 \\ 10744 \\ \hline 1128120 \end{array}$$

yards.

Double Yarns (Cotton).—Twofold yarns are numbered according to the single yarn counts—thus, 2/80's = two ends of 80's twined together, which would wrap 40's. Actually, to make the resultant count 40's, the single yarn should be finer than 80's, because the twist put in the folded yarn contracts it in length, and causes the twofold to be really coarser than would appear. However, neglecting this, supposing we twine one end of 40's and one of 20's, the counts would not be 15's, as a first glance would indicate, but 13·33. This can be proved by taking the weight of a lea of 40 = 25 grains, and of 20's = 50 grains; total, 75. 75, divided into 1000, gives the counts as $13\frac{1}{3}$.

Rule.—*Multiply the two counts, and divide by their sum*—

$$\frac{40 \times 20}{40 + 20} = \frac{800}{60} = 13\tfrac{1}{3}.$$

It is seldom that two different counts are doubled together as mentioned above. Singles of the same counts make the best doubled yarn.

To find the counts which must be doubled with another to make a given count.

Rule.—*Multiply the two counts given, and divide by their difference.*

To find counts of three or more folds of single yarn, all of one count.

Rule.—*Divide the single counts by the number of folds—thus,* 3/300's = 100's, and 4/80's = 20's.

To find counts of threefold yarns, each of different counts.

Rule.—*Take the weight of a lea of each, add them together, and divide into* 1000.

Example.—Threefold yarns of 40's, 80's, and 120's would be 21·81.

A lea of 40's = 25 grains.
„ 80's = $12\frac{1}{2}$ „
„ 120's = $8\frac{1}{3}$ „

$45\frac{5}{6}$

$$\frac{1000}{45\frac{5}{6}} = 21{\cdot}81.$$

or

Rule.—*Take the highest count, and divide it by each of the others and by itself, then divide the total of the quotients into the highest.*

Example—

$$120 \div 80 = 1\tfrac{1}{2}$$
$$120 \div 40 = 3$$
$$120 \div 120 = 1$$
$$5\tfrac{1}{2} \quad \frac{120}{5\frac{1}{2}} = 21{\cdot}81$$

From these rules the reader can easily deduce the rule for four or higher fold.

To find the Hank of Lap.

Rule.—*Divide the weight in grains of any length into its constant number (Table V.) for that length.*

Example.—If two yards weigh 24 ounces, what is the hank of the lap?

24 ounces × $437\frac{1}{2}$ grains in an ounce (Table IV.)

$= 437\frac{1}{2}$
24

1750
875

10500

The constant number or dividend for two yards is 16·66.

```
10500)16·660(·00158
      10500
      -----
       61600
       52500
       -----
        91000
        84000
        -----
         7000
```

This section on Double Yarns, and Tables III., IV., and V., are taken from "WEAVING CALCULATIONS: A Guide to Calculations on Weaving and Weaving Preparatory Processes, Cloth, Yarn, and Wages Lists." By C. P. Brooks.

CARDING.

THE most important process in cotton spinning, viz., carding, claims attention next. The cotton as it leaves the scutcher is in the form of a lap, in which the individual fibres lie in any position, in curls and flakes, while neps, small leaf, and motes are still present. The object of carding is to remove these impurities, to arrange the fibres approximately parallel, and attenuate the lap into a loose rope or strand, called sliver. The chief cards used for cotton are the following: The roller card, the revolving flat card, and the "Wellman." The other makes of cards are combinations of roller and flats. The roller card is best adapted for low and medium numbers. The revolving flat is best adapted for fine and medium numbers, and is shown in fig. 3. The "Wellman" flat is best adapted for fine and medium numbers, but is not now much used.

THE ROLLER CARD.

The object of carding is attained in this machine by the cotton being combed between the main cylinder, rollers, and clearers of the engine. This card is made both single and double. In the latter the cotton is passed to a second engine, joined to the breaker card. The single card turns out from 350lb. to 450lb. per week; the double one from 500lb. to 700lb.

The wire points with which the cylinder, doffer, rollers, and clearers are covered require grinding

frequently to keep them sharp, setting all over about every six weeks, and setting between the doffers and cylinders every three.

A good list of numbers of wire for spinning from 30's to 40's counts is—

Main	Cylinder,	No.	110
,,	Doffer	,,	130
	Rollers	,,	90
	Clearers	,,	80
	Taker-in	,,	50

Card Grinding.—When grinding the card at the commencement of a new carding engine, the emery roller should be put on very lightly, as there is a liability to knock down some of the wires and also soften them. When grinding and setting up a number of cards in a room, never grind them one after the other, as you will get both good and inferior work by this style of grinding. Well-ground cards will all be together in front; cards waiting to be ground will all be making bad work, which must go through the drawings together. The proper way to grind a preparation of cards is to take every other card, or every other two, according to size of preparation. If not done so, there will be two classes of work out of the same cotton. The cylinders and doffers should be faced up about every six or eight weeks, according to quality of cotton used.

Setting.—Set the feed rollers as near the taker-in as possible, and the taker-in rollers, clearers, and doffer as close to cylinder as possible, but on no account must any of the above touch each other. If under covers are used, they should be

set quite close, for if not set close the cotton will gather and come through in clouds, &c. There should be $\frac{3}{16}$in. between roller and clearer. To test the setting and grinding, &c., of the card, the film, as it leaves the doffer, should be examined to see if it is free from motes and dirt, even, and with clean sides.

Card Clothing.—The covering is in fillets or strips from one to two inches in width, and consist of wires fixed in an indiarubber and cloth foundation. The filleting should be put into a warm room, a few degrees warmer than the room where it is to work, so that expansion can take place. It ought to be in this room at least a week. I saw some cards that had been clothed in America, the filleting of which had not been treated in this way, but put on cold cylinders after remaining in a cold room. The result was that in the summer, when the heat got up to between 90 and 100 degrees, the filleting expanded, and, of course, the flats went up in all directions, spoiling the clothing, and doing other damage. To put on the clothing, it just requires a nice tension, not too slack nor too tight; if the former, the wire never sits well, besides not lasting as long as it should do. Before covering the cylinder and doffer, they should be thoroughly cleaned, painted, and dried. The great object in selecting the clothing is to get as many carding points as possible, as long as the wire has strength enough to keep in its position. A great deal depends on the quality of cotton going to be used.

The waste made in the carding consists of strippings from the doffer and cylinder, fly from underneath the same, and roller end pickings.

To find Circumference.

Rule.—*Multiply diameter by* 3·1416.

Example.—What is the circumference of an 18in. doffer?

```
      3·1416
          18 inches—diameter of doffer.
      ------
      251328
      31416
      ------
      56·5488 circumference of doffer in inches.
```

The circumference of a circle is equal to $3\frac{1}{7}$ times the diameter; or, to be more accurate, is equal to the diameter multiplied by 3·1416; the latter being the rule generally adopted.

Length of Filleting.

Rule.—*Multiply the circumference by the width, and divide by the width of the filleting. Add to this the circumference, for tail end and waste.*

Example.—How many feet of fillet 2in. wide will be required to cover a doffer 18in. diameter and 36in. wide?

```
Circumference  3·1416
                   18 inches diameter of doffer.
               ------
               251328
               31416
               ------
               56·5488
                   36 inches width of doffer.
               -------
               3392928
              1696464
              ---------
Width of fillet 2")2035·7568 inches.
              ---------
              1017·8784
Add circumference  56·5488
              ---------
           12")1074·4272
              ---------
Ans.—89½ft.       89·535
```

Example.—How many feet of fillet $1\frac{1}{2}$in. wide will be required to cover roller 6in. diameter and 40in. wide?

```
                     3·1416
                          6 inches diameter of roller.
                    -------
                    18·8496
                         40 width of roller.
                   --------
Width of fillet 1·5)753·9840(502·656
                    75        18·849 add once round.
                   ---        ------
                    39       521·505
                    30
                   ---
                     98
                     90
                    ---
                      84
                      75               12(521·505
                     ---                 -------
                       90                 43·459
                       90
```

Ans.—$43\frac{1}{2}$ft. nearly of fillet to cover roller.

The cylinder and clearers are just treated by the same way.

To find the Speed of Cylinder.

Rule.—*Multiply the speed of the main shaft by the diameter of pulley fixed on it for a dividend; and for a divisor take diameter of the pulley on the cylinder shaft, and the quotient will be the answer.*

Example—

```
Line shaft              145 revolutions per minute.
Pulley on line shaft     16in. in diameter.
                        ----
                         870
                        145
                        ----
                        2320
```

Pulley or cylinder shaft 14)2320(165·71 revs. of main cylinder [per minute.

```
 14
 ——
  92
  84
  ——
   80
   70
   ——
   100
    98
   ———
     20
     14
     ——
      6
```

Or thus:

$$\frac{145 \times 16}{14} = 165\tfrac{3}{4} \text{ revolutions nearly.}$$

You may take 164 as the actual revolutions, because there is always a certain amount of slippage of the belt. In the carding engine there is a large attenuation taking place, principally between the feed and the doffer. There is not generally any draft between the doffer and draw box, but there is a slight one in the draw box, except when calender rollers are used.

To find the Draft between the Feed Roller and the Doffer.

Rule.—*Multiply the driven wheels and the diameter of the doffer in inches for a dividend, and the driving wheels and the diameter of feed roller in inches for a divisor, and the quotient will be the draft required.*

Example—

Drivers.		*Driven.*	
Dia. of feed roller	2in.	Dia. of doffer	22in.
Side shaft change pinion	22 teeth	Feed roller wheel...	135 teeth
Doffer end bevel wheel..	30 ,,	Side shaft wheel ...	40 ,,

```
                                        135 feed roller wheel.
                                         22 dia. of doffer.
                                       ————
Side shaft change pinion   22           270
Dia. of feed roller ......  2          270
                          ———         ————
                           44          2970
```

	Continued—44	2970
Doffer end bevel wheel	30	40 side shaft wheel.
	1320	)118800(90 draft.
		118800

Or thus :

$$\frac{135 \times 22 \times 40}{22 \times 2 \times 30} = 90 \text{ draft between feed roller and doffer.}$$

N.B.—Wheels acting as carriers are omitted.

To find the Second Draft between the Doffer and the Draw Box.

Rule.—*Multiply the diameter of doffer, the front shaft end wheel, and the draw box back roller wheel together for a divisor, and the diameter of back roller in draw box, the card box shaft wheel, and the doffer wheel for a dividend.*

Example—

Drivers.	*Driven.*
Diameter of the doffer ...22in.	Diameter of back roller $1\frac{3}{4}$in.
The front shaft end wheel 20 teeth	Draw box shaft wheel 38 teeth.
Card box back roller wheel 27 ,,	The doffer end wheel 180 ,,

		180	doffer end wheel.
		38	draw box shaft wheel.
Card box back roller wheel	27	1440	
Front shaft end wheel	20	540	
	540	6840	
Diameter of doffer	22	1·75	diameter of back roller.
	1080	34200	
	1080	47880	
		6840	
	11880)	1197000(1·007	
		11880	
		90000	

Or thus :

$$\frac{38 \times 180 \times 1 \cdot 75}{27 \times 20 \times 22} = 1 \cdot 007 \text{ draft between doffer and card box.}$$

To find the Third Draft in the Draw Box.

Rule.—*Multiply the diameter of the draw box back roller and the driving wheel on the front roller for a divisor, and multiply the diameter of the front roller, together with the back roller wheel for a dividend; divide, and the quotient is the draft.*

Drivers.	*Driven.*
Dia. of draw box back roller, $1\frac{1}{2}$in.	Dia. of front roller draw box, $1\frac{1}{2}$in.
Wheel on front roller...22 teeth	Wheel on back roller......27in.

Example—

Dia. of back roller	1·50	1·5	dia. of front roller.
Wheel on front roller	22	27	wheel on back roller.
	300	105	
	300	30	
	33·0	)40·5(1·22	draft in draw box.
		33·0	
		750	
		660	
		900	
		660	
Or thus:		240	

$$\frac{1 \cdot 5 \times 27}{1 \cdot 5 \times 22} = 1 \cdot 22 \text{ draft in draw box.}$$

N.B.—It is not necessary to take into account the rollers when they are both of the same diameter, but I have done so in order to show how it should be calculated. Neither do we require the draw box shaft wheel (38), as it drives both rollers.

Multiply the three drafts together, and the product will be the whole draft of card.

Example—

90	draft between feed roller and doffer.
1·007	,, ,, doffer and drawbox.
630	
90	
90·630	

Continued—90·630
122 draft in the draw box.

```
    90·630
      122
  --------
    181260
   181260
   90630
 ---------
 110·56860 total draft of card.
```

To find the Hank Carding.

Rule.—*Measure 6 yards of the sliver delivered, and divide the weight of the 6 yards in grains into the dividend for 6 yards, and quotient will be the hank required.*

Example—

Suppose 6 yards weigh 14dwt. 4gr.

```
                    dwt.  gr.
                     14    4
Grains in dwt.       24
                    ---
                     56
                    28
                    ---
                    336
              Grs.    4
                    ---Const. No.
                    340)50·0(·147 hank carding.
                        340
                        ----
                        1600
                        1360
                        -----
                         2400
                         2380
                         ----
                           20
```

N.B.—If you want less draft in the card, put on a larger change pinion wheel, and for more draft a less change pinion wheel. But should the change in the weight of the sliver be great, it is better to alter the lap accordingly.

Suppose a certain length of sliver weighs 100 grains with a 22 tooth pinion on cross shaft. What wheel will be required to change the sliver to 120 grains in weight?

Rule.—*Multiply the present change pinion 22 teeth with the weight you want, and divide by the grains you are making, and the quotient will be the change pinion wanted.*

Example— 100 : 120 :: 22

```
       120
        22
      ----
       240
      240
      ----
  100)2640(26·4 pinion required.
      200
      ----
       640
       600
      ----
       400
       400
```

If 2 yards of a lap weigh 24oz., what draft will be required in the card for 2 yards of sliver to weigh 86 grains?

Rule.—*Reduce* 24 *ounces to grains, and divide by* 86 *grains, and the product will be the draft required.*

Example—

```
        437·5 grains in one ounce.
          24oz.
        ------
        1750·0
        8750
        ------
  86·0)10500·0(122· draft required.
        860
        ----
        1900
        1720
        ----
         1800
         1720
         ----
           80
```

N.B.—When the draft and the delivery of the carding engine are right for the following preparation, it is better not

to alter them, as it interferes with the rest of the machinery as regards the weight being turned off, &c.

To find the Number of Carding Engines to keep up with a given number of deliveries of drawings.

Rule.—*Multiply the revolutions of draw frame back roller per minute by its diameter and circumference, and that product by the number of the deliveries and the ends up at each delivery for a dividend; and the revolutions of the doffer per minute multiplied by its diameter and circumference for a divisor; divide, then the quotient will be the number of cards required. Suppose the revolutions of a draw frame roller be 40 per minute, and its diameter $1\frac{3}{8}$in., with three deliveries and 6 ends up at each; and the revolutions of the doffer be $6\frac{1}{4}$ per minute and its diameter 22in.: find the number of cards required to supply the three deliveries.*

Example—

Rev. of doffer	6·25	40	rev. of draw-frame back roller.
Dia. ,,	22	$1\frac{3}{8}$	dia. of back roller.
	1250	40	
	1250	15	$\frac{3}{8}$ of 40
	137·50	55	
Circum. = 1in.	3·1416	3 1416	circum. = 1 inch.
	82500	330	
	13750	55	
	55000	220	
	13750	55	
	41250	165	
		172·7880	
		3	deliveries.
		518·3640	
		6	ends up.
Inches div.	431·97000	)3110·184000(	7 cards, full.
		3023790000	
		86394000	

Or thus:

$$\frac{40 \times 1\frac{3}{8} \times 3{\cdot}1416 \times 3 \times 6}{6{\cdot}25 \times 22 \times 3{\cdot}1416} = 7 \text{ cards, full.}$$

THE REVOLVING FLAT CARD.

It is unnecessary to say anything respecting the Wellman card, as it is far from equalling the revolving flat card. I will give the particulars of this latter machine, but not the drafts, as they are got just in the same way as for the roller card. The flats seen in figure 3 revolve on a conical ring, which can be adjusted by a special arrangement to a 1000th part of an inch; also, as the cards wear, the conical rings and the flats can be lowered so as to preserve their perfect concentricity with the cylinders. The total number of flats is 110, of which 43 are always working, and which make a complete circuit in about 50 minutes, but this varies according to requirements, &c.

The flats are $1\frac{3}{8}$in. wide over all and $\frac{15}{16}$in. on the wire.

The production of this card per week for a fair quality is about 800lb., and they will produce 800lb. of as good quality in the same time (and from the same mixing) as the double roller card would produce 700lb.

Diameter of	cylinder	is	50in., and 40in. wide.	
,,	doffer	,,	26in.	,,
,,	lap roller	,,	6in.	,,
,,	licker-in	,,	$9\frac{1}{4}$in. where covered with saw teeth.	
,,	feed roller	,,	2in.	

The speed of main cylinder is about 170 revolutions per minute. In case the cylinder shaft or its bearings get worn, they can be readily adjusted to their proper place by the operating of two inclined planes upon which the cylinder reposes.

There are also under covers to this card, but no dirt roller, as it is not required.

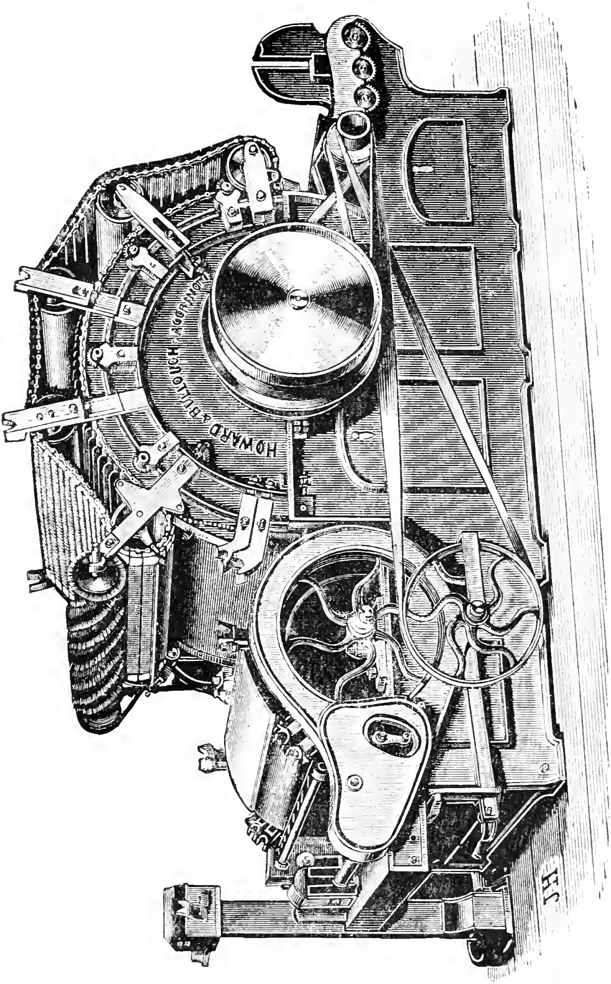

FIG. 3.—THE FLAT CARD.

The position of the flats as to their proper concentricity with the cylinder is secured by the means and operation of two circular inclined planes termed conical rings. These conical rings bear the flats, and are adjusted on each side of the card by five regulating screws of fine pitch, to which is attached an indicator, which is marked and divided from one division to another, representing a movement of one-thousandth part of an inch. Each indicator is operated upon by a key made specially for it, so that no malicious person can tamper with it. When setting for grinding, each side of the flat is operated upon separately. The grinding roller used for the purpose is a cylindrical roller covered with strips of No. $2\frac{1}{2}$ corundum. This roller is used to grind both cylinders, doffer, and flats, but finish off and point up the flats with another roller covered with a coarse emery named "stacks half forty." The cylinder is finished off with what is called a compound disc. The proper time required to grind both cylinder and doffer is about two weeks. The number of wire for above are :—

For cylinder,	No. 110's	filleting of	2 inches wide.
For doffer,	No. 120's	,,	,,
For flats,	No. 120's	,,	1 inch wide.

There is a self-stripping motion for the flats, as well as a brush to clean them.

In the setting of this machine the flats should be set with very great care at first, as, if one pillar should happen to be set wrong, it will spoil the whole carding. But if rightly set at first, there will be very little trouble afterwards.

In some mills a double process of carding is performed where fine spinning is carried on. The slivers from the first or breaker carding engines—ordinary single ones—are carried to a Derby doubler, and formed into laps, which are put up at the finisher card. Roller cards are sometimes used as the breakers, and flats as finishers. In very fine spinning mills combers are used instead of the finisher card, and the lap made from the breaker card sliver is used at the comber.

THE COMBER.

This machine, the invention of Mr. Heilman in 1850, is now largely used in fine spinning mills. It practically selects the longer fibres from the bulk of cotton submitted to its operations, leaving, also, with the short fibre the impurities and neps. The principle is, that a pair of rollers take hold of a quarter of an inch of lap, and hold it, so that a comb passes through the fibres. 70 to 90 nips per minute are made, and the production is about 160lb. per week, 10 to 12 per cent of the short fibre being thrown out. The delivery is a continuous film, issuing as a sliver, which is afterwards passed through the drawing frame as usual. Combing machines are set according to the length of the staple of the cotton you are working. The longer the staple, the greater the distance from the cushion plate to the nipping rollers. The top combs must be down in every setting. When the direct motion begins, feed and direct motion must move at the same time the top combs are down.

A gauge or sector is sometimes used to set the machine; this is a half-circle, divided into 100 parts, each one-eighth of an inch. These are arranged in ten sections, each of ten parts, *i.e.*, $1\frac{1}{4}$in., marked 1 to 10.

Rules for Setting.—

Top combs down at	3
Direct motion begins at.................	3
Feed begins at	5
Nipping begins at	3·8
Cushion begins to go back at...........	5·5

The above rule is for setting for Egyptian cotton only.

Rule for fine Sea Island cotton only :

Top combs down at	2·5
Direct motion begins at	2·5
Feed motion begins at	5·4
Nipping motion begins at	4·3
Cushion plates go back at	9

It is important that the leather rollers be covered well with Persian leather, and not be out of place; that the cushion plate be not too far from the nipper bar, or be too thickly covered ; and that the fluted segment and leather rollers be parallel, as also the fluted rollers with the brass rollers. If these points be neglected, the film of cotton as delivered will be curly.

THE DRAWING FRAME.

THIS machine, or rather series of machines, operates on the carding sliver. Several ends of the latter are put together, and attenuated to the size of one of the original slivers. By this means the two main objects of drawing are attained, viz., to draw the individual fibres parallel to each other by taking out the curl, and secondly to make the slivers of a uniform evenness and size. Occasionally the drawing frame is used as a medium for mixing two qualities of cotton in exact proportion.

The drawing frame, a front view of which is shown in fig. 4, follows the carding engine with six or eight ends up at the back to one at the delivery, although only in fine counts are eight ends used, as in ordinary American cotton six ends are better. The draft in the drawing should be as the amount of ends up at the back, or thereabouts. The top rollers should be all parallel, and each one the same diameter as its fellow, nicely oiled, varnished, and properly weighted. When the mill stops for any length of time, such as week ends or pastimes, all rollers should be unweighted, because the roller, resting in one place with the weight on it, becomes out of truth, and afterwards licking takes place, besides causing earlier recovering. The "Evan Leigh" loose boss rollers should be used in every case, as they are a great saving in oil and trouble.

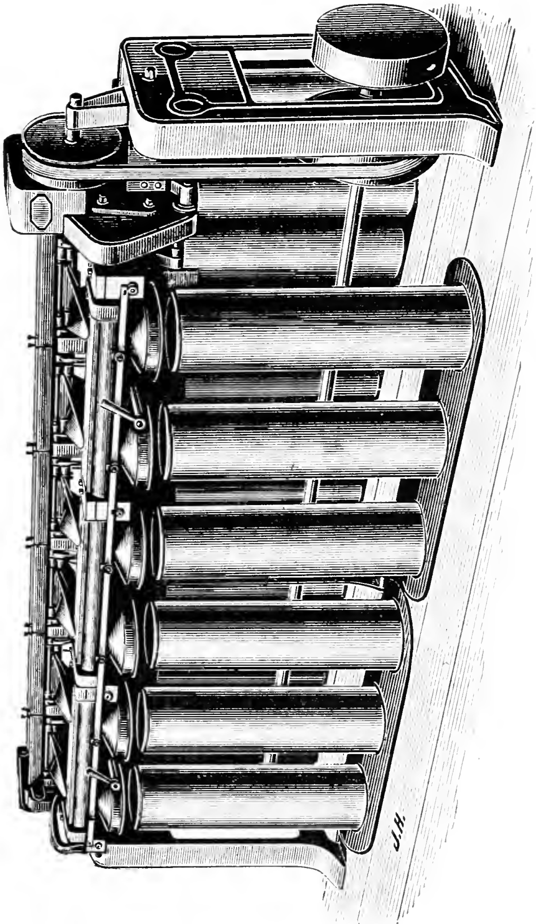

FIG. 4.—THE DRAWING FRAME (FRONT VIEW).

With the roller properly weighted and set, it should be able to draw any kind of cotton; but if not sufficiently weighted and set the right distance for the staple of cotton, you will never get good work. How to test whether the drawing is working right or not is to get five or six feet delivered, take and twist it. If it twists evenly up to the last, it is all right; but should it come thick in some places and thin in others, the rollers are not set right or they are short of weight. Hard cotton requires a good deal of weight to draw it. It is not good to draw the cotton more than three times, as it becomes soft, and licking occurs, and where that takes place there is bad work. The spoons well balanced, and stop motions nicely set, are great advantages to the drawing frame for producing good work. Also see that the top rollers are varnished when they require it, and as soon as the leather becomes a little rough they should be covered at once. You cannot be too particular in watching the rollers, both top and bottom. There is little or no waste made in this frame except what can be put back in the mixing.

An admirable piece of apparatus has of late years been applied to drawing frames. We refer to the electric stop-motion of Messrs. Howard and Bullough, of Accrington.

The four conditions that have to be provided for are: (1) a stop-motion for any sliver breaking before it reaches the drawing rollers, or, what is the same in effect, a can running empty; (2) a sliver breaking at the front between the drawing rollers and coiler—these two motions may be

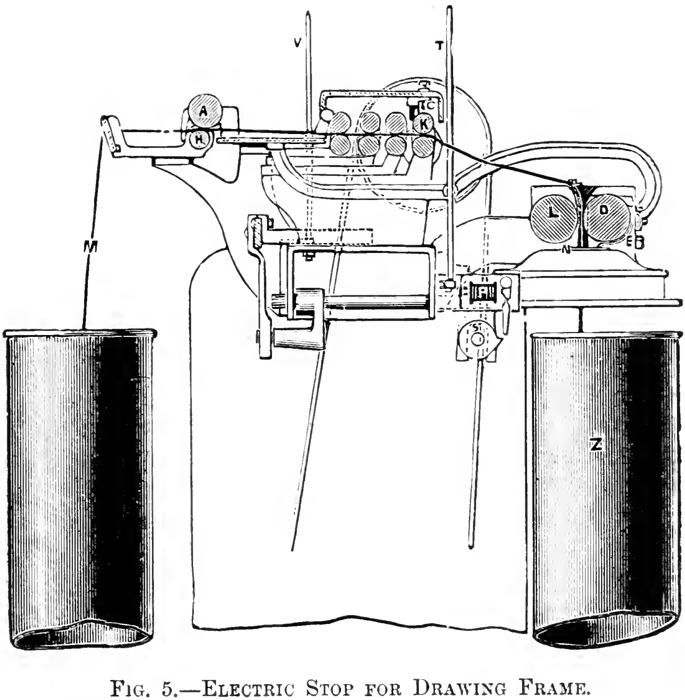

FIG. 5.—ELECTRIC STOP FOR DRAWING FRAME.

called indispensable, but there are, besides, the other two that are desirable; (3) a stop-motion for a full can in the coiler; and (4) a stop-motion when cotton laps round the drawing rollers. To show the multiplication of parts involved in mechanical stop-motions, it is sufficient to instance the ordinary spoon motion provided for the first case, viz., sliver breaking at the back. In a frame with, say, three heads of five deliveries, and doubling six ends into one, there are ninety of these delicately-balanced spoon levers, all of which have to be nicely adjusted to the size of slivers; and if they are not carefully attended to, they stick and become inoperative. Their tardiness of action is such, that if the sliver breaks near to the fluted rollers, as it generally does when it gets entangled, single is almost inevitably made; again, the broken sliver will often remain on the spoon and prevent it falling, and the machine therefore runs on, and bad work is the result.

The electric stop-motion depends for its action on the fact that cotton fibre is a non-conductor of electricity. The current is obtained from a small magneto-electric machine, which does not call for particular description, but one of which suffices for any number of drawing frames in a mill. Fig. 4 is a prospective view of the machine, and fig. 5 a section that will enable us to explain the action. The first stop is for sliver breaking at the back. The slivers, on their way to the fluted drawing rollers, pass through rollers A and H, which may be described as electric rollers. The bottom roller is fluted, and runs in bearings on the frame. The

top rollers are made short, and each rests upon a pair of slivers. They run in brackets on the back plate, which is electrically insulated from the rest of the frame, as therefore also are the top rollers. The back plate is also in electrical communication with one pole of the magneto machine, whilst the frame is likewise in connection with the other pole. The effect is that the top rollers are in communication with one pole, whilst the bottom is with the other. If they touch each other, the circuit is completed, and the current will pass. This, therefore, occurs when the sliver breaks, and allows them to come in contact. At one end of the machine is a small box called the magnet box, containing the electro-magnet P, which, when the current passes, becomes operative, and attracts a pendulum catch X within the range of a revolving cam S, and causes this to actuate the strap-fork and stop the frame. It will be understood that the machine frame itself is a conductor of electricity, but that some parts are insulated from it, and are of different pole, the electrical connection being obtained by small rods V and T. For the stop-motion, if the sliver breaks in front after passing the drawing rollers, the calender rollers L and D are utilised. They are insulated from each other; and when they come in contact by reason of a breakage of the sliver, the current passes, as before described, through the magnet, and stops the machine. Suppose, further, the sliver at this point is only partially broken, and therefore runs light. The cotton not passed on will collect in front of the rollers, and will either

choke the funnel over the coiler, or lap on the front drawing rollers. In the former case the end will break, and so cause a stoppage; and in the latter case a stoppage will also be caused, but in the following way: It may lap on either of the front rollers, but, no matter which, they will be separated, the roller K being lifted up until it makes contact with the set pin C of different electrical pole, when the current passes, and a stoppage results. Therefore, not only is a broken end at the front met directly, but if the sliver runs light by being partially broken, it also provides indirectly a stop-motion for such eventualities. For the full can stop-motion, when the can is sufficiently filled, it slightly lifts the tube wheel and completes the circuit, when a stop results as before. It will be noticed that this is equally so for all the deliveries, there being an independent stop for each; and therefore there is no risk of breakages from overfilling, as when a stop-motion is applied to one coiler only, and taken as a guide for the others.

Only one point remains to be mentioned, and that is, the stoppage is instantaneous and absolutely certain. No sooner is the circuit made, by two parts of opposite poles touching, than the current passes, and the strap is shifted; and hence, from the certainty and rapidity of the action, machines can be worked with advantage at a greatly increased rate of speed, and without the risk of making, as is usual, large quantities of waste. In fact, the production of waste is almost entirely eliminated.

To find the Speed of Front Roller.

Rule.—*Multiply speed of drawing shaft and the diameter of pulley on it together for a dividend, and use the diameter of pulley on front roller for a divisor, and the quotient will be the speed of front roller.*

Example—

```
                                   166·25 rev. of driving shaft per min.
                                       12 dia. of pulley on driving
                                   ------                      shaft.
Dia. pulley on front roller 6")199500(332·5 rev. front roller per
                                   18                            min.
                                   --
                                    19
                                    18
                                    --
                                     15
                                     12
                                     --
                                      30
                                      30
```

Traverse of Front Roller or Length Delivered.

Example—

If the speed of front roller be 332·5 per minute, and its diameter be $1\frac{1}{4}$in., what will it traverse per minute?

```
        332·5   speed of front roller per minute.
          1·25 diameter of front roller.
        ------
         16625
         6650
        3325
        -------
        415·625
         3·1416 circumference when the
     ----------           diameter is one inch.
     2493750
     415625
   1662500
   415625
 1246875
 --------------
 1305·7275000 = 1305¾ inches nearly = front roller
                                    traverse per minute.
```

N.B.—The diameter of the draw frame rollers depends on the staple of cotton. The longer the staple, the greater the diameter of rollers required.

To find the Draft of Drawing Frame.

Rule.—*Multiply all the driven wheels and the diameter of front roller together for a dividend, then all the drivers and the diameter of back roller together for a divisor, and the quotient will be draft required.*

To make it easier, put the diameter of the rollers in eighths.

Drivers.	*Eighths.*	*Driven.*	*Eighths.*
Dia. of back roller...	9	Dia. of front roller...	10
Front roller wheel ...	40 teeth	Stud wheel............	90 teeth
Change pinion wheel	33 „	Back roller wheel ...	80 „

Example—

```
     9
    40
   ———
   360     10
    33     90
   ———    ———
  1080    900
 1080      80
 ————    ————
 11880   )72000(6·06 draft of drawing frame.
          71280
          —————
            72000
            71280
```

Or thus:

$$\frac{10 \times 90 \times 80}{9 \times 40 \times 33} = 6 \cdot 06 \text{ draft of drawing.}$$

To find the Draft between the First and Second Rollers.

Rule.—*Multiply the front roller wheel and the wheel that drives the second roller and the diameter of the second roller for a divisor, and the wheel that is driven by the front roller, together with the wheel on the end of second roller, and the diameter of front roller for a dividend; divide, then the quotient will be the draft.*

N.B.—The other drafts between the rollers are got in the same manner, leaving out the diameters of the rollers when they are both of the same diameter.

To find the Draft between the Rollers without using the Wheels.

Rule.—*Multiply the revolutions of the front roller per minute by its diameter for a dividend, and multiply the revolutions of the second roller per minute by its diameter for a divisor; then the quotient will be the draft.*

Example—

The revolutions of front roller per minute, 324, and $1\frac{1}{4}$in. diam.
,, second ,, 150, ,, $1\frac{1}{8}$in. diam.

Revolutions of second roller	150	324	revol. of front roller per min.
Diameter ,, ,,	9	10	diameter ,, ,,

1350)3240(2·4 draft.
2700
5400
5400

Or thus:

$$\frac{324 \times 10}{150 \times 9} = 2{\cdot}4 \text{ draft between rollers.}$$

To find the Draft between the Rollers when their diameters are both the same.

Rule.—*Divide the revolutions of the slow roller per minute into the revolutions of the quick roller per minute; then the quotient will be the required draft.*

Example—

The revolutions of quick roller per minute, 150
,, slow ,, ,, 96

96)150(1·5 draft.
96
540
480
60

To find the Hank Drawing.

Rule.—*Weigh* 6 *yards sliver, and divide the weight in grains into the dividend for* 6 *yards.*

Example.—Suppose 6 yards sliver weigh 13dwt. 8gr.

```
                     dwt. gr.
                      13   8
Grains in dwt.        24
                     ----
                      52
                     26
                     ----
                     312
           Grains      8
                     ----Dividend.
                     320 ) 50·0 ( ·15 hank drawing.
                           320  ----
                           ----
                           1800
                           1600
                           ----
                            200
```

To find the Hank Drawing, having the Hank Carding given.

Rule.—*Multiply the hank carding by the drafts at each head of drawing, and divide by the number of ends up at each head.*

Example.—Hank carding, ·147. The drafts of the three heads are, first 6, second 6, third $6\frac{1}{4}$. There are 6 ends up at each head.

```
                                  6   draft  at   first head.
                                  6     ,,        second ,,
                                 --
                                 36
                                  6·25  ,,        third  ,,
                                  ----
                                   180
                                   72
                                 216
                                 ------
                                  225·00
Doublings, 1st head.      6         ·147 hank carding.
                                  ------
   ,,      2nd   ,,       6       157500
                         --
                         36       90000
```

```
         Continued—36       90000
Doublings, 3rd head.   6      22500
                      —     ————————
Total doublings          216·0000)33·07500(·153 hank drawing.
                                  21·60000
                                  ————————
                                  11475000
                                  10800000
                                  ————————
                                    6750000
                                    6480000
                                    ———————
Or thus :                            270000
```

$$\frac{6 \times 6 \times 6{\cdot}25 \times {\cdot}147}{6 \times 6 \times 6} = {\cdot}153 \text{ hank drawing.}$$

Changing Pinions.—To find a Wheel to change from one weight of a Sliver to another.—Suppose 6 yards sliver weigh 320 grains, with a 33 change pinion, what change pinion will you require to make 6 yards weigh 290 grains? To make 6 yards weigh 290 grains you must have a less change pinion; therefore, put 320 grains in the first term, 290 grains in the second, and 33 the change pinion given, in the third term; multiply and divide, then the result will be the change pinion required.

Example—

```
Grains.          Grains.     Change pinion.
 320      :        290     : :     33
                    33
                  ————
                   870
                  870
                  ————
             320)9570(29·9 or 30 change pinion
                 640                      required.
                 ————
                 3170
                 2880
                 ————
                  2900
                  2880
                  ————
                    20
```

Again suppose: Should ·25 hank require a 24 change pinion, what will ·20 hank require?

Hank.		*Hank.*		*Change pinion.*
·20	:	·25	::	24
		24		
		100		
		50		
		20)600(30 change pinion required.		
		60		

N.B.—The front rollers of the three heads of drawings generally run all the same speed.

SLUBBING, INTERMEDIATE AND ROVING.

THE slubbing, intermediate, roving, and jack roving frames, or, as they are sometimes called, the speeds or fly frames, are all on one principle of construction, and the calculations given for one practically apply to all. A front view of these machines is shown at fig. 6, and a back view in fig. 7.

Each of the machines carries a back creel to hold the feed bobbins, with the exception of the first frame, the slubbing, which is fed from the drawing cans. The sliver from the bobbin or can is carried to three pairs of rollers, between which it is passed, and as the middle and front pairs revolve more quickly than the back one, the sliver is drawn out. At this stage it gets too thin to carry its own weight without breaking, and therefore has to be slightly twisted to give it strength. This is done by passing the thread or end through the centre of a flyer, revolving rapidly. After having been twisted the end passes down a hollow leg of the flyer, and is wound on a bobbin encircled by it. The speed at which the thread is coiled is regulated by the size of the bobbin and the difference in speed between the bobbin and flyer revolving with and around it.

In addition to the motions for drawing and twisting, there are arrangements for winding it on the bobbin, traversing the bobbin to wind evenly, reversing the traverse at each end, shortening the

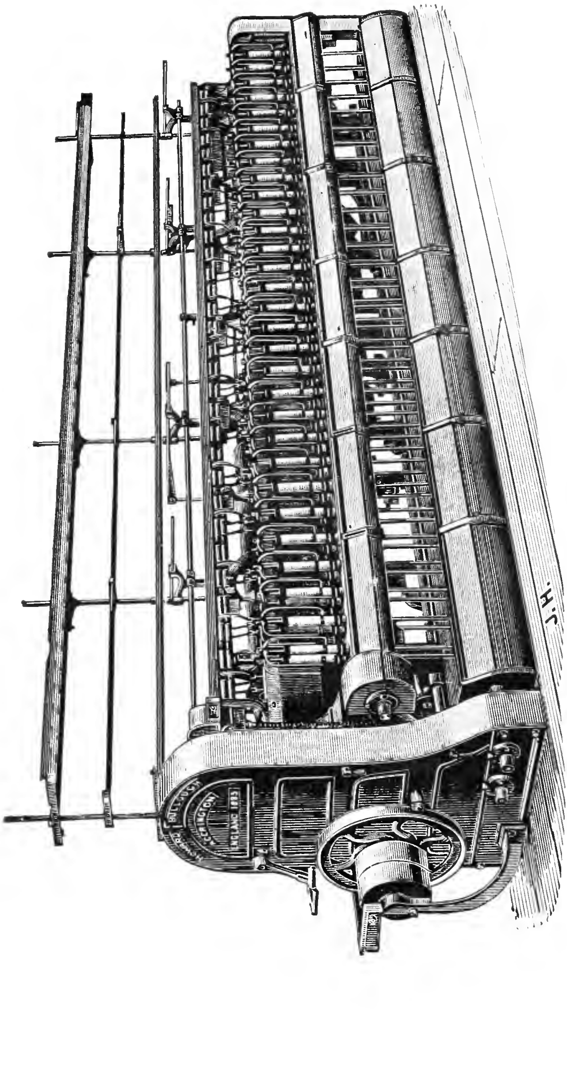

Fig. 6.—Slubbing or Roving Frame (front view).

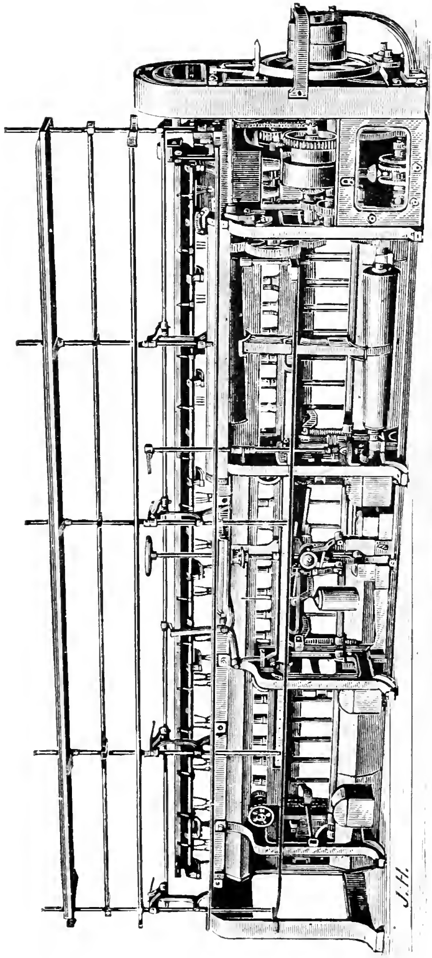

FIG. 7.—SLUBBING OR ROVING FRAME (BACK VIEW).

traverse as the bobbin gets larger to form sloping ends, and alteration of the bobbin's speed as it increases in size.

The latter idea of automatically accelerating or retarding the speed of the bobbin in relation to the spindle appears to have been first broached by a Macclesfield man named Green, who patented, in 1823, a plan for that purpose. Though practicable, it was so complex, cumbrous, and destructive, that it never got much beyond the stage of experimentation. The central idea, however, was taken up by Mr. Holdsworth, and after a couple of years' study he overcame all the difficulties that stood in the way by the invention of his differential system, one of the most beautiful examples of automatic equation that has ever been devised. Beyond the addition of a balance wheel, this arrangement until now has not been improved upon since it left the hands of its inventor, 60 years ago. This proves the great merit of the invention and the high degree of skill with which it was wrought out.

A brief description of Holdsworth's invention may be permitted, for which purpose we introduce an illustration showing it as now generally in use (fig. 8). In the slubbing, intermediate, and roving frames there are three main factors to deal with, namely, drawing rollers, the spindle, and the bobbin. The two former revolve at a constant speed, the latter at a constantly varying one—that is, with a bobbin-lead arrangement it commences at its maximum rate, which is slightly diminished every time a layer of rove is deposited

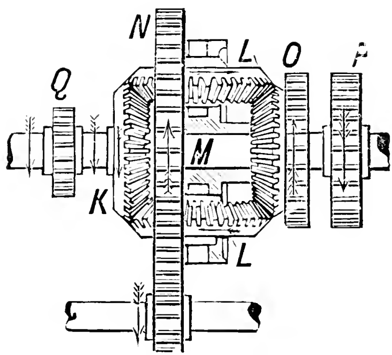

FIG. 8.—THE DIFFERENTIAL MOTION (SECTION).

upon it, until the bobbin is filled, when its rate of revolution is very nearly reduced to that of the spindle. With the flyer leading this arrangement is reversed. As the delivery of rove from the front rollers is at an unvarying rate, it is required that the winding surface of the bobbin shall take it up in the same manner. This surface being a constantly enlarging one, it becomes necessary, in order not to stretch the rove, that its rate of revolution shall be retarded in exact ratio to its increased surface. Hence the requirement of the "differential arrangement" for driving. This is the problem Mr. Holdsworth had to solve, which he accomplished by the method shown in the illustration (fig. 8), which we proceed to describe.

It must be borne in mind that the power to drive all the parts of the machine is derived from its main shaft, which has a uniform and constant revolution. A proper train of wheels drive the drawing rollers at a uniform speed; another train drives the spindles also uniformly from the wheel P upon the main shaft M. These are what we may term the constants. We have now to get at the variants, the bobbin, and the mechanism which drives it. Power is taken from the main shaft through the wheel Q to the top cone drum, one of a pair, by the use of which the variant capability is brought in. From the top cone drum power is transmitted by means of a strap to the bottom cone, upon the axle or shaft of which is fixed a small pinion wheel R, gearing into the sun wheel N. Upon the wheel N two lugs are cast to form

bearing for the wheels L, L_1, through the first of which the power is transmitted to the wheel O, whilst L_1 is an idle or at most a balance wheel. The bevel wheel K is the main driver of the arrangement. Being fixed to the shaft and revolving with it in the direction indicated, it turns the wheel L, as marked, this again causing the bevel to which the wheel O is cast to revolve in the direction shown, which, it will be observed, is opposite to the revolution of the main shaft. The wheel N, and those connected with it, are necessarily loose upon the shaft M, to admit of their revolution and variable movement in the opposite direction. If the bottom cone pinion R was not moving, the rate of revolution transmitted from the bevel K through the wheel L to the bevel attached to the wheel O would be exactly equal to the shaft M upon which it is fixed. Thus the wheel O driving the bobbins would revolve at the same rate as the wheel P driving the spindles, only the revolution of the two wheels would be in opposite directions; and spindles and bobbins as a consequence, would revolve exactly at the same rate, in which state no winding could take place. The power to diminish or accelerate the rate of revolution is derived, as we have traced from the cones. As the wheel N driven by the cone pinion R revolves in the direction of its arrow, the speed of the wheel L, and its connection, the wheel O, are accelerated in exact ratio; and thus the excess speed of the bobbin over the spindle is obtained. At the commencement of a set the bobbin must run at its maximum rate, and

the machine therefore, begins its work with the cone strap upon the largest diameter of the driving cone, and upon the smallest of the driven cone. With the deposit of every layer of rove upon the bobbin the strap is traversed a little distance from the largest diameter of the top cone, and each successive change, until with a full bobbin the minimum diameter is reached, giving the minimum rate of revolution to the bobbin.

Doffing.—All the bobbins are doffed at once when at their full size. The cone strap is slackened to prevent a few inches being wound, which are used to form the "gaiting" for the new bobbin.

The usual rules for finding the necessary twist per inch for these processes are:

Slubbing—Turns per inch equal square root of hank.

Intermediate—Turns per inch equal square root of hank by 1·1.

Roving—Turns per inch equal square root of hank by 1·2.

Of course these rules are not arbitrary, but may be varied for different qualities of cotton.

Example—What turns per inch are required for 4-hank roving? Square root of 4 = 2?
$2 \times 1{\cdot}2 = 2{\cdot}4$ turns per inch.

The best maximum drafts for these frames are generally considered to be:—

Slubbing	4
Intermediate	5
Roving	6

Best work is got by keeping under these.

The following is an example of counts and draft for 30's twist.

Drawing	·2 hank.
Slubbing, 4 draft, 1 end up, making	·8 hank.
Intermediate, 4 draft, 2 ends up, making ...	1·6 hank.
Roving, 5 draft, 2 ends up making 4 hank roving.	

In changing finer on these frames you require a

Smaller change pinion	Rule given page 90
Smaller twist wheel	,, ,, ,, 98
Larger rack wheel	,, ,, ,, 99

THE SLUBBING FRAME.

THE slubbing frame is the machine which follows the drawing frame, and is the first machine where any important twisting of the sliver commences, which should only be sufficient to carry the roving from the creels to the rollers. There is no hard and fast rule for getting the twist in the cardroom, as different qualities of cotton require more or less twist according to the cotton used. The rule previously given is approximate. The above frame consists generally of three rows of rollers, sometimes four being used, but I do not see much advantage to be gained by it. The top leather rollers should be well attended to as to their being similar in size, also as to their being well oiled and varnished. The setting of the rollers the right distance to draw the cotton is another thing which should be carefully attended to. The lift motion requires carefully watching. When winding the slubbing on to the bobbin (which may be a 10in. or 12in. lift) have the layers just so close together that you are only able to see between them. If you make a change in the hank you are making, alter your lift in proportion. The rack or ratchet wheel on your reversing motion should be well watched as to its letting off equal distance on both sides. Should this not be the case, it will cause tight and slack winding, and, of course, bad and uneven work. The cone belt should be kept the right tension, and a very even piecing, so as not

to cause the cone to jump. Should you change from one hank to another, or portion of a hank, change all your wheels in proportion to change made. The wrapping at this machine should be very exact; get on the right draft wheel, and do not allow a few grains over or under, but have it exactly the thing. Should the wrapping not come out satisfactorily at the slubber, there must be something wrong at the drawing, which should be set right at once.

To find the Revolutions of Spindles per Minute.

Rule.—*Multiply the drivers and the speed of driving shaft together for a dividend, and the driven together for a divisor; the quotient will be the revolutions.*

Main driving shaft	150 rev. per minute	—driver.
Dia. of pulley on ditto.........	24in.	,,
Dia. of frame end pulleys ...	12in.	driven.
Frame end shaft wheel.........	50 teeth	driver.
Wheel on end of spindle shaft	50 ,,	driven.
Bevel wheel on spindle shaft .	46 ,,	driver.
Spindle foot wheel	23 ,,	driven.

Example—

	Driven.	*Drivers.*
		150 rev. of main shaft.
		24 dia. of pulley.
		600
		300
Dia. of pulley	12	3600
Teeth	50	50 teeth.
	600	180000
Teeth	23	46 teeth.
	1800	1080000
	1200	720000
	13800	)8280000(600 rev. of spindles per minute.
		82800

Or thus:

$$\frac{150 \times 24 \times 50 \times 46}{12 \times 50 \times 23} = 600 \text{ rev. of spindles.}$$

To find the Revolutions of Front Roller per minute.

Rule.—*Multiply all the drivers and speed of driving shaft together for a dividend, and all the driven together for a divisor; the quotient will be the revolutions of front roller per minute.*

Example—

Driving shaft..................	150	revolutions per minute	—driver.
Dia. of pulley on ditto	24	inches	—driver.
Dia. of frame end pulley ...	12	,,	—driven.
Twist wheel	36	teeth	—driver.
Cone shaft wheel	40	,,	—driven.
Frame end cone shaft wheel	70	,,	—driver.
Front roller wheel............	150	,,	—driven.

	Driven.	*Drivers.*	
		150	rev. of main shaft.
		24	pulley on ditto.
		600	
		300	
Teeth	40	3600	
Pulley	12	36	teeth.
	480	21600	
Teeth	150	10800	
	24000	129600	
	480	70	teeth.
	72000	)9072000(126	rev. of front roller per minute.
		72000	
		187200	
		144000	
		43200	
		43200	

Or thus:

$$\frac{150 \times 24 \times 36 \times 70}{40 \times 12 \times 150} = 126 \text{ rev. of roller.}$$

To find the Traverse of Front Roller or Length Delivered per minute.

Rule.—*Multiply speed of front roller by its circumference; the circumference is the diameter* × 3·1416.

Example.—Front roller $1\frac{1}{4}$in. diameter, making 126 revolutions per minute: what will it traverse?

```
    126 revolutions of front roller.
   1·25 diameter of front roller.
   ----
    630
   252
  126
  -----
 157·50
 3·1416 equal to circumference of 1.
 ------
  94500
 15750
63000
15750
47250
-----------
494·802000 = 494¾ in. delivered per minute.
```

To find the Turns put in per inch.

Rule.—*Divide the revolutions of the spindles by the length delivered from the front roller (per minute).*

Example—

```
                              Revolution of spindles per minute.
Length delivered per minute 494·80)600·00(1·21 turns per in.
                                   49480
                                   ------
                                   105200
                                    98960
                                   ------
                                     62400
                                     49480
```

To find the Draft.

Rule.—*Multiply the driving wheels and diameter of back roller together for a divisor; and the driven wheels and diameter*

of front roller together for a dividend; the quotient will be draft.

Drivers.		*Driven.*	
Front roller wheels	25 teeth.	Crown wheel.........	90 teeth.
Change pinion......	40 „	Back roller wheel...	45 „
Di. of back roll. 1 in.	8 eighths.	Di. of front roll. $1\frac{1}{4}$in.	10 eighths

Example—

```
              90
              45
             ----
     25      450
     40      360
    ----     ----
   1000     4050
      8       10
   ----    ------
   8000    )40500(5·06 draft required.
            40000
            ------
             50000
             48000
```

Or thus:

$$\frac{90 \times 45 \times 10}{25 \times 40 \times 8} = 5{\cdot}06 \text{ draft.}$$

N.B.—The amount of draft can be increased according to the quality of the cotton. A good quality of cotton will stand more draft than inferior cotton. The first and second roller should be set from centre to centre, one-eighth further apart than the length of the staple of cotton used.

To find a Change Pinion to produce a given Draft.

Rule.—*Multiply the given draft, the front roller wheel, and diameter of back roller together for a divisor; and the crown wheel, back roller wheel, and the diameter of front roller together for a dividend; the quotient will be the change pinion required.*

Drivers.		*Driven.*	
Given draft	5	Crown wheel...........	90 teeth
Front roller wheel ...	25 teeth	Back roller wheel......	45 „
Dia. of back roller 1 in.	8	Dia. of front roller $1\frac{1}{4}$in.	10in.

Example—

Given draft	5	90	crown wheel.
Front roller wheel	25	45	back roller wheel.
	25	450	
	·10	360	
	125	4050	
Dia. of back roller	8	10	dia. of front roller.

1000)40500(40·5 change pinion.
4000

5000
5000

Or thus:

$$\frac{90 \times 45 \times 10}{5 \times 25 \times 8} = 40 \text{ or } 41 \text{ change pinion required.}$$

Constant Number for Draft:—

A simpler method is to find a constant number or dividend for the draft wheels, and the change pinion can then always be easily found by dividing the draft into this constant number.

Rule.—*Proceed just as in the rule given for finding the draft, but leave out the change pinion, and it will give you a dividend for any change wheel or draft.**

Driver.		*Driven.*	
Front roller wheel ...	25 teeth	Crown wheel	90 teeth
Dia. of back roller 1 in.	8	Back roller wheel ...	45 ,,
		Di. of front roller $1\frac{1}{4}$in.	10

Example—

	90
	45
	450
	360
25	4050

* The above rule for finding a constant number applies to all the machines in carding and spinning rooms. A number for the twist per inch can be got in the same way by leaving out the twist change gear.

```
Continued—25   4050
           8     10
         ---------
         200)40500(202·5 constant number.
             400
             ---
               500
               400
               ---
               1000
               1000
```

How to Prove that the Constant Number is Right.

Rule.—*Divide draft required into the constant number, 202·5, then the quotient will be the change pinion.*

Example—

```
Draft required 5·06)202·50(40 change wheel required.
                    2024
                    ----
                      10
```

To find the Slubbing Hank or Counts.

Rule.—*Measure a certain length and divide its weight in grains into the dividend for that length (Table V.).*

Example.—What is the hank of slubbing of which 15 yards weight 5dwt. 5gr.?

```
               dwt.    gr.
                5       5
        dwts.  24
               --
               20
              10
              ---
              120
      grains    5
              ---   dividend.
              125    )125( 1 hank slubbing.
                      125
```

Changing Pinion.—If 1 hank slubbing requires a 40 change pinion, what will $1\frac{1}{2}$ hank require to make the change?

Rule.—*Multiply the hank you are making by the change pinion you have on, and divide by the hank wanted; then the answer will give the change pinion wheel.*

Hank.		*Hank.*		*Pinion.*
1·5	:	1	::	40

```
        40
       ----
 1·5)40·0(27 change pinion nearly.
     30
     ----
     100
     105
```

THE INTERMEDIATE FRAME.

THE above frame follows the slubbing, and has two ends up at the back. I will suppose a frame making a two-hank intermediate bobbin from a one-hank slubbing, which, having two ends up at the intermediate, will be equal to half-hank; it, therefore, must have four of a draft to make a two-hank bobbin. I will only give a few examples on this machine, as its arrangements are so like the slubbing that I do not think it necessary to dwell further upon it.

To find the Draft of Intermediate Frame apply Rule given for Slubbing.

Drivers.		*Driven.*	
Front roller wheel ...	25 teeth	Crown wheel	90 teeth
Change pinion.........	45 ,,	Back roller wheel	40 ,,
Dia. of back roller 1 in.	8	Dia. of front roller $1\frac{1}{4}$in.	10

Example—

$$\begin{array}{rr} 25 & \\ 45 & \\ \hline 125 & 90 \\ 100 & 40 \\ \hline 1125 & 3600 \\ 8 & 10 \\ \hline 9000 &)36000(\text{ 4 draft required.} \\ & 36000 \end{array}$$

Or thus:

$$\frac{90 \times 40 \times 10}{25 \times 45 \times 8} = 4 \text{ of a draft.}$$

To find the Weight Produced per Week by the Machine.

Rule.—*Multiply the number of hanks done per week by the number of spindles in frame, and divide product by the hank of intermediate roving being made; then the answer will be the weight in pounds.*

Example.—Suppose the above machine of 90 spindles turns off 40 hanks of a two-hank roving per week, how much weight will it turn off in pounds?

```
                 40 hanks per week.
                 90 spindles.
               ----
Hank roving 2)3600
               ----
               1800 pounds.
```

Example II.—Suppose also an intermediate frame of 100 spindles turns off 52 hanks of a one and a half hank roving per week, how much weight will it turn off in pounds?

```
                 52 hanks per week.
                 100 spindles.
               -----
Hank roving 1·5)5200·0(3466·6 or 3466½lb. good.
                45
                --
                 70
                 60
                 --
                 100
                  90
                 ---
                  100
                   90
                  ---
                  100
                   90
```

THE ROVING FRAME.

THE roving frame is the next machine after the intermediate. On the latter machine we were making a two-hank bobbin, and from that we will make a six-hank roving with two ends up, which will require six of a draft, having two ends up it makes it equal to one hank. I would again remind the reader about the setting of the rollers; to have a space between the centre of front roller and centre of middle roller, about one-eighth of an inch more than length of staple of cotton used. All rollers should be in a perfect line, and great attention should be paid to the leather rollers to see that they do not become hollow, as if so the roving will pass through without any drawing taking place, and bad yarn be caused, there being only one doubling after to help to rectify it. Where single roving is used on the mule the roving becomes the yarn, only draft and twist taking place afterwards.

To find the Draft of Roving Frame.

Drivers.		*Driven.*	
Front roller wheel ...	25 teeth	Crown wheel	100 teeth.
Change pinion	37 ,,	Back roller wheel......	50 ,,
Dia. of back roller 1in.	8 ,,	Dia. of front roller $1\frac{1}{8}$in.	9 ,,

Example—

25	
37	
175	100
75	50
925	5000

Continued—925 5000
8 9

7400)45000(6·08
44400

60000
59200

Or thus:

$$\frac{100 \times 50 \times 9}{25 \times 37 \times 8} = 6{\cdot}08 \text{ draft.}$$

To find the Twist per inch by the Wheels, not having any revolutions of Front Roller and Spindles given.

Rule.—*Begin first with the spindles gear, and multiply all the driving wheels* together, and that product by the circumference of the front roller for a divisor; likewise multiply all the driven wheels together for a dividend; the quotient will be the turns per inch.*

Wheel on spindle	22	teeth	driver.
,, ,, shaft...............	55	,,	driven.
,, end of spindle shaft	50	,,	driver.
Main driving shaft	50	,,	driven.
Twist wheel	24	,,	driver.
Wheel on centre of top cone shaft...	55	,,	driven.
,, end of top cone shaft......	78	,,	driver.
,, end of front roller	140	,,	driven.
Dia. of front roller	$1\frac{1}{8}$	inch	driver.

$1\frac{1}{8}$in. equals in circumference 3·534in.

Example—

22
50

1100
24

4400

* In this connection we must consider the wheel on spindle and wheel on end of spindle shaft, driving shaft as drivers, and wheel on frame driving shaft, and on spindle shaft as driver, though in reality they are *vice versa.* The reason for taking them thus is that they form part of the train of wheels from the twist wheel to the front roller in this problem.

Continued—4400
2200
———
26400 55
78 50
———
211200 2750
184800 55
———
2059200 13750
3·534 13750
———
8236800 151250
6177600 140
10296000 6050000
6177600 151250
———
7277212·800)21175000·0(2·9 turns per inch.
145544256
———
662057440
654949152
———
7108288

Or thus :

$$\frac{\text{Driven } 55 \times 50 \times 55 \times 140}{\text{Drivers } 22 \times 50 \times 24 \times 78 \times 3\cdot534} = 2\cdot9 \text{ turns per inch}$$

Constant Number for Twist Gear.—It is advisable to find a constant number which can be divided by the twist required, and thus give the twist wheel quickly, or when divided by the twist wheel will give the turns.

Rule.—*Multiply just as in the former rule for getting the twist per inch, but leave out the twist change pinion, and the quotient will be the constant number. Divide the turns per inch required into the quotient, then the answer will be the twist pinion required.*

Example—

$$\frac{55 \times 50 \times 55 \times 140}{22 \times 50 \times 78 \times 3\cdot534}$$

22	
50	
———	55
1100	50
78	———
———	2750
8800	55
7700	———
———	13750
85800	13750
3·534	———
———	151250
343200	140
257400	———
429000	6050000
257400	151250
———	———

303217·2) 21175000·0(69·83 constant number.
18193032
———
29819680
27289548
———
25301320
24257376
———
10439440
9096516
———
1342924

Having found the constant number, find what twist pinion will be required for 2·9 turns per inch.

Example—

Const. No.
Turns per inch 2·9)69·83(24 twist pinion.
58
———
118
116
———
23

To find a Twist Wheel in changing from one hank to another.

Suppose that you are making a four-hank roving with a thirty-twist pinion, and you wish to make a five-hank roving, what twist wheel will be required?

Rule.—*Multiply the square of the twist wheel on by the hank roving you are making, and divide by the hank roving required; then the square root of that quotient will be the twist wheel required.*

Example—

30
30
———
900 square of twist wheel.
4-hank roving.
———
Hank roving required 5)3600
———
2) 720(26·83 nearly 27-twist wheel required.
2 4
———
46) 320
6 276
———
528) 4400
8 4224
———
5363) 17600
16089

To find the Twist Wheel when changing from one hank to another without using the square root.

Rule.—*Multiply the hank you are making by the twist wheel you have on, and divide by the hank required. Add the twist wheel you have on to the quotient, and divide that by 2, then the answer will be the new twist wheel.*

Suppose that you are making a 4-hank with a 30-twist wheel, what twist wheel will be required for a 5-hank?

Example— *Hank.* *Hank.* *Twist wheel.*

5 : 4 :: 30
30

5)120

24
30 twist wheel added.

2)54

27 twist wheel required.

N.B.—The above rule is not quite so correct in its results as the preceding one by that using the square root, but it is near enough for practical purposes. You can also use this rule to make the changes in frames, mules, ring frames, and throstles for the twist wheels; also a somewhat similar one for rack wheels, builder wheels, and rim pulleys on the mules.

How to find a Rack Wheel when changing from one hank to another.

Rule.—*Multiply the hank you require by the rack wheel you have on, and divide by the hank making; then average this result with the rack wheel using.*

Example.—Suppose that you are making a 4-hank roving with a 24-rack wheel, and you wish to make a 5-hank roving, what wheel will you require?

Hank. *Hank.* *Rack wheel.*

4 : 5 :: 24
24

20
10

4)120

30
24 rack wheel added.

2)54

27 rack wheel required.

Again, suppose that you are making a 4-hank roving with a 24-rack wheel, and you wish to make a 3-hank roving, what rack wheel will you require?

Example—

Hank.		*Hank.*		*Rack wheel.*
4	:	3	::	24

```
   24
 ----
   12
   6
 ----
 4)72
 ----
   18
   24 rack wheel added.
 ----
 2)42
 ----
   21 rack wheel required.
```

How to find a Rack Wheel in changing from one hank to another or part of a hank, using the square root.

Rule.—*Square the rack wheel which you have on, and multiply it by the hank roving required; divide that by the hank roving you are making; then the square root of the quotient will be the rack wheel required.*

Example.—Suppose that you are making a 4-hank roving with a 24-rack wheel on, and you wish to make a 5-hank roving, what rack wheel would be required?

Hank.		*Hank.*		*Rack wheel.*
4	:	5	::	24

```
                   24
                 ----
                   96
                  48
                 ----
                  576 square of each wheel.
                    5 hank roving required.
                 ----
Hank roving 4)2880
```

Continued—Hank roving 4)2880

```
              4)2880
              ------
                2)720(27 each wheel nearly.
                  4
                -----
               47)320
                  329
```

To find the Turns per inch for a 6-hank Roving of the ordinary quality of cotton.

Rule.—*Multiply the square root of the hank roving by* 1·2.

Example.—What turns per inch will a 16-hank roving require? First get the square root of the 6-hank roving.

```
  Hank.
2 )6 (2·44 square root of 6-hank roving.
2  4
----
44)200            2·44
 4 176             1·2
------            ----
484)2400           488
    1936          244
    ----          -----
     464          2·928
```

Example.—What turns per inch will a 6-hank roving require? First get the square root of 16-hank roving.

```
Hank.
4)16(4
  16              4  square root.
                1·2  common multiplier.
               ----
                  8
                4
               ----
                4·8  turns per inch required.
```

To find the Hank Roving.

Example.—Suppose 30 yards of roving weigh 1dwt. 17gr., what hank will it be?

```
                 Dwt.  Gr.
                  1    17
Grains in dwt.   24
                 --
                 24
                 17
                 -- constant dividend
                 41)250(6-hank roving.
                     246
                     ---
                       4
```

Example.—Suppose 20 yards of roving weigh 1dwt. 9gr., what hank will it be?

```
                 Dwt.  Gr.
                  1     9
Grains in dwt.   24
                 --
                 24
                  9
                 -- constant dividend.
                 33)166(5-hank roving.
                     165
                     ---
                       1
```

Example.—Suppose 30 yards of roving weigh 1dwt. 1gr., what hank will it be?

```
                 Dwt.  Gr.
                  1     1
Grains in dwt.   24
                 --
                 24
                  1
                 -- constant dividend.
                 25)250(10-hank roving.
                     25
                     ---
                      0
```

To find the Weight of a given length of Carding, Drawing, Slubbing, or Roving of a given hank.

Rule.—*Take the constant dividend (Table V.) for the length or sliver given for a dividend, and divide it by the given hank; the quotent will be the weight in grains.*

Example—

What will 8 yards of carding of a ·12-hank weigh?

Constant dividend.

```
Given hank ·12)66·66(555·5 grains.
               60
               --
                66
                60
                --
                 66
                 60
                 --
                  60
                  60

             Gr.
1oz. = 437·5)555·5(1oz.
             437·5
             -----
1dwt. = 24gr.)118(4dwt.
               96
               --
               22
```

Ans.—1oz. 4dwt. 22gr. = weight of 8 yards of ·12-hank.

Example.—What will 10 yards of slubbing of a ·85-hank weigh?

Constant dividend.

```
Given hank ·85)83·33(98 grains.
               76·5
               ----
               6·83
               6·80
               ----
                  3
1dwt. = 24gr. )98(4dwt.
               96
               --
               2gr.
```

Ans.—4dwt. 2gr. = the weight of 10 yards of a ·85-hank.

Example.—What will 30 yards of roving of a 3-hank weigh?

```
           Constant dividend.
Given hank 3)250(83·3 grains.
             24
             ---
              10
               9
             ---
               10
                9
```

or 3dwt. 11·3gr., the weight of 30 yards of a 3-hank.

Example.—What will 120 yards of roving of a 10's yarn weigh?

```
            Constant dividend.
Given hank 10)1000(100 grains.
              10
              ---
               00
```

or 4dwt. 4gr., the weight of 120 yards of a 10-hank.

To find the Capacity of a Roving Frame.

Rule.—*Multiply the number of spindles in the frame with the quantity of hanks turned off per week for a dividend; and for a divisor take the hank roving made; divide, and the quotient will be the weight in pounds.*

Example.—Suppose a frame of 160 spindles in length be turning off 40 hanks per week of a 6-hank roving, what will be the weight in pounds?

```
                   160 spindles in frame.
                    40 hanks per week.
                  ----
Hank roving made 6)6400(1066·6lb. per week.
                   6
                   ---
                    40
                    36
                    ---
                     40
                     36
```

Example.—Suppose a frame to be turning off 45 hanks per week of a 5-hank roving with 120 spindles, what will be the weight in pounds?

```
                     120 spindles in frame.
                      45 hanks per week.
                    ----
                     600
                    480
                    ----
Hank roving made 5)5400(1080lb. per week.
                   5
                   ----
                    40
                    40
```

MULE SPINNING.

Four sorts of machines are used for completing the attenuation—the self-actor mule, ring frame, hand mule, and throstle frame. The two latter are fast disappearing in consequence of the great improvements over the hand mule recently made in the self-actor mule, so as to spin fine counts up to 300's, and in the increased output of the ring over the throstle frame. The mule is automatic in all its movements for spinning the yarn and winding it on the spindle in the form of a cop—*i.e.*, a cylindrical coil of yarn, cone-shaped at each end. In this machine the spinning is intermittent—*i.e.*, for a few seconds the different portions of the machines are engaged in drawing out the roving to the required fineness until about 64 inches have been spun; the slack being taken up by a moving carriage bearing the spindles, then a few seconds are employed in drawing back the carriage and winding the yarn on the spindles. The ring frame is a constant spinner, and as fast as the yarn is spun it is wound on a bobbin, while the necessary twist is put in by a traveller shaped ⊂⊃ revolving round a ring. It will thus be seen that the ring frame is only suited for warp yarns, mainly in consequence of having to use a bobbin, which of course requires modifications in the shuttle and box of the loom, and even then is disadvantageous. The ring frame is suitable and

preferable for warp yarn up to 40's, where the spinner also reels, warps, or weaves his own spinning. The mule spins both weft and twist. Throstle twist (or, as it is called when reeled or warped by the spinner, water twist) is generally admitted to be the evenest and roundest thread, ring twist being next best, and mule yarn inferior to both. Mule yarn, however, possesses an elasticity which neither of these can boast of.

The mule can be used equally well for twist and weft.

For the former they are made about 90 doz., or 1,080 spindles in one mule, and in the latter as high as 108 doz., or 1,296 in one mule.

The machine shown in fig 9 consists of a moving carriage, containing the spindles in one long row, and having a traversing motion to and from the roller beam. This carries the three sets of rollers to attenuate the roving which comes from the bobbins in the creel fixed behind the roller beam.

The process of spinning a thread consists of the carriage moving away from the roller beam for about 60 inches, and carrying the thread which is being delivered from the rollers at the same time. As the carriage retreats the spindles are rapidly revolving and twisting the thread. When the carriage gets to the end of its "stretch" the spindles stop, the rollers having already ceased delivering and caused the gain in the carriage, which is the result of its travelling over more ground than the length the roller is delivering. The amount of gain in the carriage is regulated

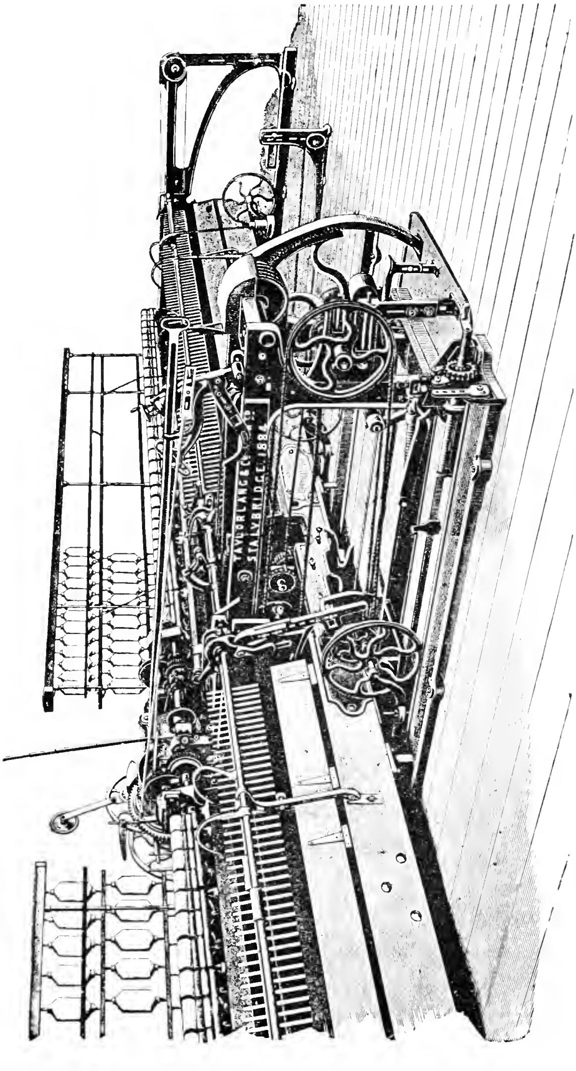

Fig. 9.—Spinning Mule (front view).

according to the quality of cotton, and is generally 3 inches. It gives great elasticity to yarn, and at the same time helps to keep down the snarls. By one action of what are called "faller" wires the threads are conducted lower down the spindle where it is desired to coil the yarn. The carriage is then drawn up to the roller beam, the spindles revolving slowly and winding the yarn in a layer on the last spun yarn in the form of a "cop." This process is continually repeated until the cops attain their full size, when they are all doffed at once, and a new set commenced.

The twist yarn is twisted more than the weft, the turns per inch being found by multiplying the square root of the counts by 3·8. For weft, the square root is multiplied by 3·2. Some spinners use 3·75 and 3·25 respectively.

The general range of drafts in spinning is from 5 to 9. Thus a 4-hank roving could be used for a range of yarns from $5 \times 4 = 20$'s to 36's $= 4 \times 9$.

The back pair of rollers are set generally about $\frac{1}{4}$ to $\frac{3}{8}$ of an inch more than length of staple apart, and between front and middle a space equal to $\frac{1}{16}$in. or $\frac{1}{8}$in. more than length of staple is left.

In changing finer there are required—

Smaller change pinion.
Larger builder.
Larger twist wheel.

Some makes require smaller twist wheel.

The mule is a very complicated machine, and requires keeping in proper order. The roller beam and carriage must be level, square, and in line one

with the other. On fine pitched mules, Evan Leigh's loose boss rollers cannot be used to advantage, as the bosses are too short; therefore the top rollers will need greater attention in respect of being nicely oiled and well cleaned. The same with the steel rollers: these also should be well attended to, as the only thing to keep down wear and tear is to attend to the oiling, &c. The rim and spindle bands should be well watched as to their right tension, so as to insure the required amount of twist, as the strength of the yarn greatly depends on the proper amount of twist being put in. Different qualities of cotton require different twist in the mules, just as in the preparation. It is impossible to make good yarn from bad roving. Should the roving be badly carded or not properly drawn, or be cut with the roller, and not have sufficient twist to carry it properly from the creel to the rollers at the intermediate or roving frame, it would be sure to cause irregularities and thin places in the roving and a great amount of breakage on the mules, besides the yarn being spun unevenly and not up to required strength.

The Draft in the Mule.—Having previously given calculations for a 6-hank roving, and it being required to spin 48 counts, we must therefore have 8 of a draft.

To find the Draft without any gain in the carriage.

Drivers.		*Driven.*	
Front roller wheel......20 teeth.		Crown wheel.........120 teeth.	
Draft change pinion ...45	,,	Back roller wheel ... 60	,,
Dia. of back roller 1in. 8		Dia of front roller 1in. 8	

Example—

```
Front roller wheel  20
Change pinion       45
                   ----
                   100  120  crown wheel.
                   80    60 back roller wheel.
                   ---  ----
                   900  7200
                     8    8 dia. of front roller 1in.
                   ----------
                   7200)57600(8 of a draft.
                        57600
```

Or thus : $\dfrac{120 \times 60 \times 8}{20 \times 45 \times 8} = 8$ of a draft.

To find the Constant Number as a Dividend for the above Wheels.

Rule.—*Multiply and divide as above, but leave out the change pinions, and the quotient will be the constant number.*

Example—

```
          120
           60
          ----
     20   7200
      8      8
   -----------
   160)57600(360 constant number.
        480
        ----
         960
         960
```

Proof— Constant number.

```
Draft required 8)360(45 change wheel for above draft.
                 32
                 --
                 40
                 40
```

How to find the Change Wheel.

Rule.—*Multiply and divide as in getting the draft, only leave out the draft change pinion, and in its place put the*

required draft; then the quotient will be the change pinion required.

Example—

Drivers.	*Driven.*
Front roller wheel ...20 teeth	Crown wheel ....120 teeth
Draft required ...... 8 ,,	Back roller wheel...... 60 ,,
Dia. of back roller 1 in. 8	Dia. of front roller 1 in. 8

Front roller wheel	20	120	crown wheel.
Draft required	8	60	back roller wheel.
	160	7200	
Dia. of back roller	8	8	diameter of front roller.

1280)57600(45 draft wheel.
5120

6400
6400

Or thus:

$$\frac{120 \times 60 \times 8}{20 \times 8 \times 8} = 45 \text{ draft wheel required.}$$

N.B.—It is a great advantage in cotton spinning to have large change wheels both in draft and twist, as when you change a tooth in a large wheel it does not make such a great difference in the draft or twist as it would should you change a tooth in a small change pinion.

To find the Draft required for any Counts of Yarn when the hank roving, the counts, and the gain in the carriage are given.

Rule.—*Multiply the counts and the length delivered from the roller together for a dividend; and for a divisor multiply the length of stretch and the hank roving; then the quotient will be the draft required.*

Example.—What will be the draft of a mule spinning 52's from a 6-hank roving with 63 inches stretch and the roller delivering 60 inches?

```
                          60  inches delivered from rollers.
                          52  counts given.
                         ----
Length of stretch  63    120
Hank roving         6   300
                  ----  ----
                378)3120(8·25 draft required.
                    3024
                    ----
                      960
                      756
                      ----
                      2040
                      1890
```

To find the Counts of Yarn being spun, the hank roving, the draft, the length of stretch, and the amount delivered by the roller being given.

Rule.—*Multiply the hank roving, the draft, and length of stretch together for a dividend; and for a divisor take the length delivered from the rollers; then the quotient will be the counts required.*

Example.—Suppose that you have a draft of 10 with a 6-hank roving, the length of stretch 63 inches, and 59 inches being delivered from roller, what will be the counts of yarn?

```
                                 10 draft.
                                  6-hank roving.
                                 --
                                 60
                                 63  inches length of stretch.
                                ---
                                 180
                                360
                                ----
Inches delivered from roller 59)3780(64 counts.
                                354
                                ---
                                 240
                                 236
                                 ---
                                   4
```

Example.—Again, suppose that you have a draft of 10 with a 12-hank roving (double), the length of stretch 63 inches, and 59 inches being delivered from roller, what will be the counts of yarn ?

```
                                    10 drafts.
                                    12 double-hank roving.
                                   ----
                   Two ends up 2)120
                                   ----
                                    60
                                    63 length of stretch.
                                   ----
                                   180
                                  360
                                  ----
Inches delivered from roller 59)3780(64 counts required.
                                354
                                ----
                                 240
                                 236
```

To find the Change Pinion in changing from one count to another.

Rule.—*Multiply the counts you are spinning by the wheel on, and divide the product by the counts wanted.*

Example.—Suppose you are spinning 48's with a 45 change pinion, what pinion will be required to spin 40's ?

```
                              48 counts spinning.
                              45 change pinion.
                             ----
                             240
                            192
                            ----
Counts required, 40's )2160(54 change pinion required.
                       200
                       ----
                        160
                        160
```

Example.—Again, suppose you are spinning 60's with a 36 change pinion, what pinion will be required to spin 64's ?

```
                     60 counts spinning.
                     36 change pinion.
                    ---
                    360
                   180
                   ----
Counts required, 64's )2160(34 change pinion nearly.
                       192
                       ---
                        240
                        256
```

To find the Speed of Mule Spindle per Minute.

Rule.—*Multiply the revolutions of the rim shaft pulley per minute by its diameter, and that product by the diameter of tin rollers in carriage for a dividend, and for a divisor multiply together the diameters of the tin roller end pulleys and the spindle wharves; divide, then the quotient will be the revolutions of the spindle.*

Example:—

Revolutions of rim shaft per minute	....	420 driver.
Diameter of rim or twist pulley	....	22in. driver.
,, tin roller	....	6in. ,,
,, tin roller end pulley	....	10in. driven.
,, spindle wharves	....	$\frac{3}{4}$in. ,,

```
                                         420 rev. of rim shaft.
                                          22 dia. of twist pulley.
                                         ----
Dia. of tin cylinder pulley  10           840
 ,,   spindle wharves        ·75         840
                            ----        ----
                             50         9240
                            70             6 dia. of tin roller.
                           ----        -----
                           7·50)55440·00(7392 = rev. of spindles
                                5250               per minute.
                                ----
                                 2940
                                 2250
                                 ----
                                  6900
                                  6750
                                  ----
                                   1500
                                   1500
```

Or thus:

$$\frac{420 \times 22 \times 6}{10 \times \cdot 75} = 7392 = \text{rev. of spindles per minute.}$$

To find the Turns per Inch, having the Revolutions of the Spindles and Rollers given.

Rule.—*Take the revolutions of the spindles per minute for a dividend, and multiply the revolutions of front roller by its circumference for a divisor; then divide, and the quotient will be the turns per inch.*

Example—

Revolutions of spindles per minute......... 7392
„ front roller „ 92
together with its diameter, 1in., equals 3·1416 circumference.

```
          3·1416 the circumference of 1in.
              92 revolutions of front roller per minute.
          ------
           62832
         282744
         ---------rev. of spindles
         289·0272) 7392·0000)25·57 turns per inch.
                   5780544
                   --------
                   16114560
                   14451360
                   --------
                    16632000
                    14451360
                    --------
                     21806400
                     20231904
```

Or thus:

$$\frac{7392}{92 \times 3\cdot 1416} = 25\cdot 57 \text{ turns per inch.}$$

or about right turns for 48's twist.

To find the Revolutions of the Spindle for one of the Rim.

Rule.—*Multiply the diameter of the rim twist pulley by the diameter of tin cylinder for a dividend, and for a divisor multiply the diameter of the tin cylinder pulleys by the diameter of the spindle wharves; the quotient will be the turns of spindle for one of rim.*

Example—

```
  10  diameter of tin cylinder pulley.
 ·75     „       „ spindle wharve.
────
  50             22 diameter of rim pulley.
 70               6     „      „ tin cylinder.
────           ────
7·50   )132·00(17·6 turns for one of rim.
         750
         ────
         5700
         5250
         ────
          4500
          4500
```

Or thus: $\dfrac{22 \times 6}{10 \times \frac{3}{4}} = 17\frac{1}{2}$ turns for one rim.

To find a Twist or Rim Pulley when changing from one counts to another without altering the speed of Front Roller.

Rule.—*Multiply the square of the diameter of the present twist pulley by the counts you wish to spin for a dividend; and for a divisor take the counts you at present spin; then the square root of the quotient will be the diameter of the pulley required.*

Example.—Suppose that you are spinning 42's, with a 20in. twist pulley, what diameter of twist pulley will 48's require?

```
                 20  inch.
                  20  inch.
                 ────
                 400  square of twist pulley.
                  48  counts.
                 ────
                3200
               1600
               ──────
Counts 42)19200(457
           168
           ────
            240
            210
            ────
             300
             294
```

```
2      )457  (21·37, or 21⅜ diameter of pulley required.
2       4
—      —
41     ) 57
 1       41
———    ———
423    )1600
  3     1269
———    ———
4267   ) 33100
          29869
```

If it is not desirable to use the square root use the following:

Rule.—*Multiply the counts intended to be spun by the present rim pulley, and divide by the present counts. To the quotient add the present size of pulley, and divide by 2.*

Example—

```
                     48 × 20 ÷ 42
                          48
                          20
                         ———
                      42)960(22·85
                         84
                         ———
                         120
                          84
                         ———
                          360
  22·85                   336
  20·00                  ———
  ———                      240
2)42·85
  ———
  21·42
```

This result is not exact, but is sufficiently near for practical purposes.

To find the Turns per inch for Mule Twist and Weft Yarns

Rule.—*Multiply the square root of the counts wanted by* 3·8 *for twist, and for weft by* 3·2; *then the quotient will be the turns per inch required.*

Example I.—

What will be the twist per inch for 48's twist?
The square root of 48 is 6·9282. This multiplied by 3·8 will give the twist.

$$\begin{array}{r} 6{\cdot}9282 \\ 3{\cdot}8 \\ \hline 554256 \\ 207846 \\ \hline 26{\cdot}32716 \end{array}$$

26·32716 twist per inch for 48's twist.

Example II.—

What will be the twist per inch for 48's weft?
6·9282 × 3·2 will give the twist.

$$\begin{array}{r} 3{\cdot}2 \\ \hline 138564 \\ 207846 \\ \hline 22{\cdot}17024 \end{array}$$

22·17024 twist for 48's weft.

Example III.—

What will be the twist per inch for 64's twist?
The square root of 64 is 8. This multiplied by 3·8 will give the twist.

$$\begin{array}{r} 3{\cdot}8 \\ 8 \\ \hline 30{\cdot}4 \end{array}$$

Ans.—30·4 twist for 64's twist.
What will be the twist per inch for 36's weft?
The square root of 36 is 6. The twist required is 6 × 3·2.

$$\begin{array}{r} 3{\cdot}2 \\ 6 \\ \hline 19{\cdot}2 \end{array}$$

19·2 twist for 36's weft.

To find the Builder Wheel in changing from one counts to another.

Rule.—*Multiply the square of the wheel by the counts going to be spun for a dividend, and for a divisor use the present counts being spun. The square root of the quotient will be the builder wheel required.*

Example.—Suppose a mule be spinning 60's with 25 builder wheel on, what will 50's require?

```
                25 builder wheel.
                25      ,,
               ----
               125
                50
               ----
               625
                50
              -----
Counts     60)31250(521
               300
              -----
               125
               120
              -----
                50       2)521(22·8, nearly 23, builder required.
                60       2)4
                         --  ---
                         42 )121
                          2   84
                        ---  ---
                        448 )3700
                             3584
```

Although the above rule is correct theoretically, the builder wheel will vary very much as to the number of teeth in the different mules spinning the same counts. The reason is that the copping rails and the shaper thread on the worms are not all alike.

To find the Builder Wheel in changing from one counts to another without using the square root.

Rule.—*Multiply the builder wheel on by the counts required for a dividend, and for a divisor use the present counts being spun, add to that quotient the builder wheel being used, and divide that product by 2; then the answer will be the builder wheel required.*

Example.—Suppose a mule to be spinning 60's with a 25 builder wheel on, what wheel will 50's require?

Counts.		*Counts.*		*Builder wheel.*
60	:	50	::	25

25

250
100

Counts 60)1250

---

21 nearly.
25 builder wheel added.

---

2)46

---

23 builder wheel nearly.

Example.—Suppose a mule be spinning 40's with a 30 builder wheel on, what wheel will 36's require?

Counts.		*Counts.*		*Builder wheel.*
40	:	36	::	30

30

---

40)1080

27
30 builder wheel added.

---

2)57

28·5 required, *i.e.*, either 28 or 29.

To find the Twist Pulley in changing from one counts to another.

Example.—Suppose that you are spinning 50's with a 22-inch twist pulley, what diameter of twist pulley will 40's require?

Counts.		*Counts.*		*Twist pulley.*
50	:	40	::	22

22

80
80

880

Continued—50)880(
17·6
22·0 added.

2)39·6

19·8 twist pulley required.

Example.—Again, suppose that you are making a 6-hank bobbin with a 30-twist wheel, what twist wheel will a 5-hank require? 6 : 5 :: 30
30

6)150

25
30 added.

2)55

27·5 twist wheel required is either 27 or 28.

To find the Weight of one Set of Cops.

Suppose the mule contains 900 spindles, the number of stretches being 1100, and the counts of yarn 48's, with a stretch of 64 inches.

Rule.—*Multiply the number of spindles together with the stretches, and the length of stretch for a dividend, and for a divisor multiply the counts of yarn being spun by* 840 *(the yards in one hank) and* 36 *(the inches in one yard); then the quotient will be the weight of the set.*

900 number of spindles.
1100 number of stretches.

90000
900

990000
64 length of stretch.

3960000
5940000

63360000 dividend.

```
         48 counts of yarn.
        840 yards in 1 hank.
       ----
       1920
      384
      -----
      40320
         36 inches in 1 yard.
     ------
     241920
    120960
    -------
    1451520 divisor.

1451520)63360000(43lb.
        5806080
        -------
         5299200
         4354560
         -------
          944640
              16 ounces in 1lb.
         -------
         5667840
         944640
         -------
1451520)15114240(1oz.
        1451520
        -------
          599040
```

Ans.—43lb. $1\frac{1}{2}$oz. nearly, equals the weight of the set of cops.

THE RING FRAME.

This machine, shown in fig. 10, has been largely adopted of recent years for the production of twist yarn below 40's. The creel and rollers are somewhat on the principle of the roving frame. The fibres when delivered from the rollers are twisted by means of a spindle, which drags the yarn round a ring. The yarn is attached to the ring by a sliding traveller, shaped ⊂⊃, so as to clip the edges of the ring. The spindle, which carries a bobbin, winds the yarn on as fast as the rollers deliver it, and as the ring rail has a vertical traverse, the thread is coiled on the cop principle. The following is a description of the principal spindle —the Rabbeth—made by Messrs. Howard and Bullough.

Fig. 11 shows the spindle in section. It consists of a steel spindle A running in the cast-iron bolster D. The whole is secured on the spindle rail or girder by the single nut K. The foot and the collar at foot are turned and faced to gauge, and the rail being planed on the top and drilled, the bolsters are fitted on readily and accurately. The single nut securing the whole is one of the good features. In the bolster runs the light steel blade or spindle A, upon which is fastened the cast-iron sleeve B, at the bottom of which is the wharve C. On the sleeve, close to the wharve, is the brass cup F, which receives the bottom of the spool or bobbin G. The bobbin closely fits the spindle at

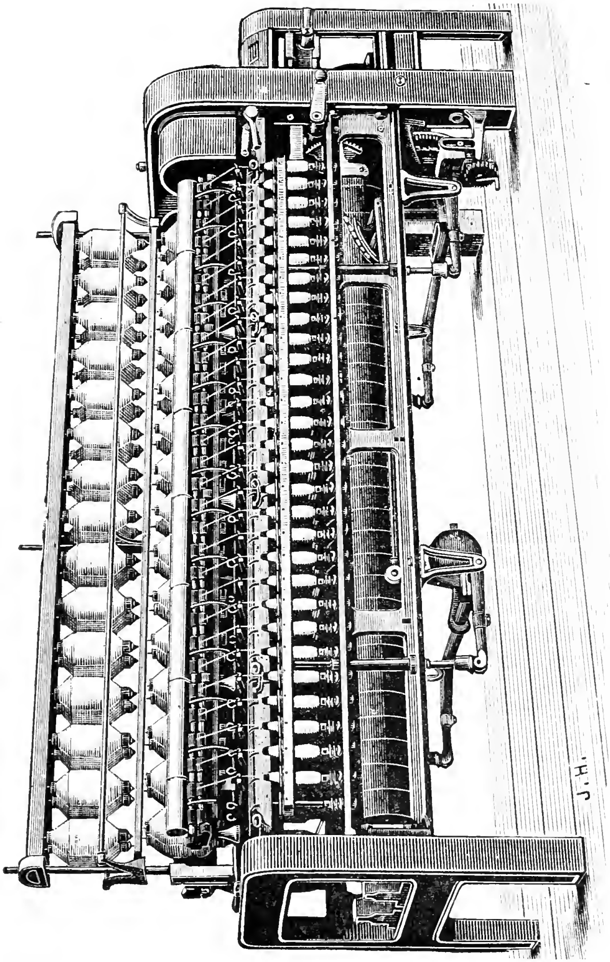

Fig. 10.—The Ring Frame.

the top, and is carried round by the friction at this point. The brass cup serves the double purpose of centreing the bobbin and preventing it flying out of balance, and also of helping to carry it round by the spindle, thus making the driving doubly sure.

A feature that greatly conduces to the steadiness of running of the Rabbeth spindle is that the bolster bearing is situated nearly at the middle of the bobbin—that is, at the centre of the revolving weight. This bearing is bushed with a phosphor bronze bush E, which, when worn, may be renewed with the greatest facility. Referring to the section, fig. 11, there are two other points that require notice. These spindles run at all speeds up to 9,000 revolutions per minute, or even higher, and therefore it is indispensably necessary that the lubrication should be perfect. The clearance space between the spindle and bolster is filled with oil, which lubricates both the bolster bearing and the spindle foot, the quantity of oil being sufficient for several months' running, but it is advisable to replenish, say every six weeks or two months. We understand in regular work the cleaning out of the bolsters is not required. This brings us to the second point, viz., that the oil is perfectly protected from external influences, or the addition of dirt, fly, and other foreign matter. An inspection of the section fig. 11 will make it clear that it is almost impossible for dirt or cotton fibre to pass between the bolster and the sleeve B up to the bearing, through which again it would have to pass before it reached the oil. The protection of

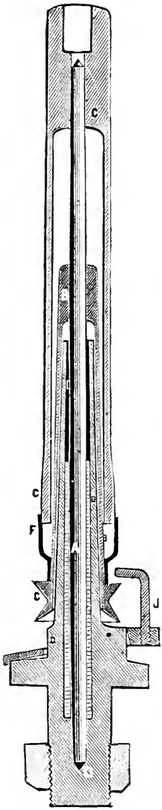

FIG. 11.

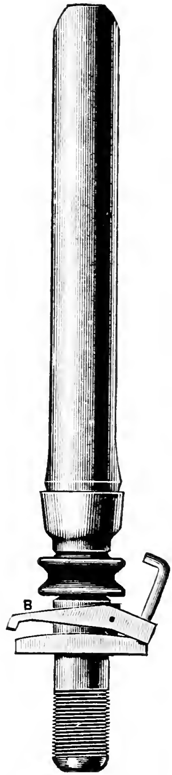

FIG. 12.

THE RING SPINDLE.

the latter from contamination is as perfect as practicable, and it is stated, as representing the small consumption of lubricant, that one gallon of oil is sufficient for 1,000 spindles running a whole year. It may be mentioned here that the weight of the moving parts of the spindle is about $3\frac{3}{4}$oz., and, as regards the power to drive them, it has been found that, taking an average with 30,000 spindles, spinning 30's, 5in. lift, and 6,500 speed of spindles, it required 1 indicated horse power for 132 spindles. This may be varied from several causes.

One of the great merits of the Rabbeth, and of spindles made in substantially the same way, is that it facilitates doffing, by obviating the necessity of tying the ends on to the empty bobbins in commencing a new set, thus obviating the necessity of doffing motions. The result is attained in a very simple way. In removing the full bobbin, the ring rail is at the lowest position for the commencement of a new set of bobbins, leaving an amount of slack end between bobbin and traveller, which coils itself in a very coarse thread once or twice round the spindle. When the empty bobbin is put on it bites the end in the cup as securely as if it were tied, although no special operation has been required. In starting the machine the yarn commences winding on the proper part of the bobbins, the edge of the cup preventing it being wound too low. The brass cup therefore achieves several very important objects in the simplest possible way.

The latest improvement is the automatic spindle-holder, the action of which will be understood by

a reference to fig. 12. The object of this arrangement is to hold down the spindles when doffing, to prevent their being lifted with the full bobbins, but at the same time to permit the spindle being easily lifted out for oiling. The old plan is to have a bent wire, the bend being over the wharve. Before the spindle can be lifted out this has to be turned on one side with a key, and when the spindle is replaced the holding wire has to be turned back again. In Messrs. Howard & Bullough's new patent spindle-holder the bent wire is screwed on a plate or lever, pivoted as shown in the illustrations. By lifting the front of the plate (the left-hand side in the illustrations) with the finger the spindle is at once released. (See fig. 12.) Unless the holder is turned over as thus described the spindle cannot be lifted, but when the spindle is replaced the holder automatically permits it to drop in its place, the holding-down wire falling to the right, as in fig. 12. The arrangement seems both simple and effective.

For coarser yarn a heavier traveller is used. The number of spindles in a ring frame is usually 320—160 on each side. The spindle makes about 8,000 to 9,000 revolutions per minute. The rollers are generally set at angle to allow the yarn to receive the twist right up to the nip of the top and bottom rollers. In starting new ring frames, make it a rule to have your drafts on the light side, as the yarn runs up when the twist is being put in. Suppose you are intending spinning 48's, make your drafts for 50's at the least. You may draft the ring frame anywhere between 5 and 9 to advantage. When calculating for the twist or

the amount the roller delivers, instead of multiplying 1in. roller by 3·1416, multiply it by 3, and it will make up for the contraction in the yarn when the twist is put in. The bands which drive the spindles should be well watched and kept in proper order as regards the right tension.

The ring frame has made great progress in the cotton industry for warp yarns; but has not as yet been brought to any great advantage for weft yarns, partially because it is not adapted for soft twisted yarn, but principally because it requires the use of a bobbin, which is a nuisance to the weaver in weft yarn and requires specially-adapted shuttles. In coarse twist the ring frame produces more than the mule or throstle.

To find the Revolutions of the Spindle per minute, having the revolutions of the cylinder given.

Rule.—*Multiply the revolutions of the cylinder per minute by its diameter for a dividend, and for a divisor use the diameter of the spindle wharves.*

Example.—Suppose that the cylinder makes 650 revolutions per minute and its diameter be 10 inches, the diameter of the spindle wharve being $\frac{7}{8}$in., how many revolutions will the spindle make per minute?

650 rev. of cylinder per minute.
10in. dia. of cylinder.

$\frac{7}{8}$in. = ·875)6500·000(7428 rev. of spindle per minute.
6125

3750
3500

2500
1750

7500
7000

It is not necessary to give a rule for the draft for this machine, as it is got in the same way as for the previous machines.

To find the Turns per Inch, no speed being given.

Rule.—*Multiply all the driven wheels and the diameter of the cylinder together for a dividend, and for a divisor multiply all the driving wheels together with the circumference of front roller and diameter of spindle wharves; then the quotient will be the turns per inch.*

Wheel on front roller end............	90 teeth driven.
Arm wheel..............................	120 ,, ,,
Wheel on cylinder end...............	41 ,, driver.
Twist pinion	29 ,, ,,
Diameter of cylinder..................	10 inches driven.
,, ,, spindle wharves.........	$\frac{7}{8}$,, driver.
The front roller's circumference...	3 ,,

Cylinder end wheel, 41	120 arm wheel.
Twist wheel 29	10 dia. of cylinder.
369	1200
82	90 front roller wheel.
1189	108000
Circum. of front roller 3	7 spindle wharve.
3567	28536)756000(26·49 turns per inch.
Spindle wharve 8	57072
28536	185280
	171216
	140640
	114144
	264960
	256824

Or thus: $\dfrac{10 \times 120 \times 90 \times 7}{41 \times 29 \times 3 \times 8} = 26{\cdot}49$ turns per inch.

To find the Constant Number for the Twist.

Rule.—*Proceed as in getting the turns per inch, but leave out the twist change pinion.*

Example :—

```
                                     120  arm wheel.
                                      10  dia. of cylinder.
                                   ------
Cylinder end wheel          41      1200
Circum. of front roller      3        90  front roller wheel.
                          ----     ------
                           123    108000
    Spindle wharve           8         7  spindle wharve.
                          ----     ------
                           984   )756000(768·29 constant number
                                  6888
                                  ----
                                   6720
                                   5904
                                   ----
                                    8160
                                    7872
                                    ----
                                     2880
                                     1968
                                     ----
                                      9120
                                      8856
```

Or thus :

$$\frac{10 \times 120 \times 90 \times 7}{41 \times 3 \times 8} = 768 \cdot 29 \text{ constant number.}$$

To find the Twist Change Pinion.

Rule.—*Divide turns per inch required into constant number, then the quotient will be twist pinion required.*

Example—

```
                 Constant number.
Turns per inch 26·49(768·29(29 twist change pinion.
                     5298
                     -----
                     23849
                     23841
```

All the turns of spindle are not put in the yarn, as part of them are lost in winding on.

Deduct 5 per cent allowed for winding on, which will give the real and practical constant number.

$$
\begin{array}{l}
100 : 768 :: 5 \\
\quad\quad\quad 5 \\
\hline
100(3840(38 \\
\quad 300 \\
\hline
\quad\quad 840 \\
\hline
\quad\quad 40
\end{array}
\qquad
\begin{array}{l}
768 \text{ constant number.} \\
\ \ 38\ 5\% \text{ taken off.} \\
\hline
730 \text{ real constant number.}
\end{array}
$$

The twist varies on the ring frame according to the quality of cotton used. When spinning fair American cotton the square root of the counts multiplied by 4 will give the turns per inch.

Rule.—*Multiply the square root of the counts by 4; then the product will be the turns per inch required for any counts (twist).*

What will be the twist per inch required for 36's twist?

The square root of 36 is 6 which × 4 will give the twist.

$$
\begin{array}{r}
4 \\
\hline
24
\end{array}
$$

24 twist per inch for 36's twist.

What will be the twist per inch required for 20's twist?

The square root of 20 is 4·47 which × 4 will give the twist.

$$
\begin{array}{r}
4 \\
\hline
17{\cdot}88
\end{array}
$$

17·88 twist per inch for 20's twist.

To find the Draft to produce a given Number of Counts from a given Hank Roving.

Rule.—*Divide the counts by the hank roving, the quotient will be the draft required.*

Suppose you are going to spin 48's from a 6-hank roving, what will be the required draft?

Hank roving 6)48(8 of a draft required.
48

To find the Hank Roving required to spin certain counts, having the draft and counts given.

Rule.—*Divide the counts by the draft, the quotient will be the hank roving.*

Suppose you are spinning 48's with 8 of a draft, what hank roving will you require?

Given draft 8)48(6 hank roving required.
48

Suppose you are spinning 20's with 7 of a draft, what hank roving will you require?

Example—

Given draft 7)20(2·85 hank roving required.
14

60
56

40
35

TWIST TABLE.

The following is a table of the turns per inch for mule and ring frame yarns.

RULE.—Multiply the square root of the counts for the mule twist by 3·8, weft by 3·2, and the ring frame twist by 4.

Counts or Nos.	Root Square.	Mule Twist.	Weft Twist.	Ring Twist.	Counts or Nos.	Square Root.	Mule Twist.	Weft Twist.	Ring Twist.
10	3·1622	12·01	10·11	12·64	56	7·4833	28·43	23·94	29·8
11	3·3166	12·50	10·61	13·26	57	7·5498	28·68	24·15	30·19
12	3·4641	13·163	11·08	13·85	58	7·6157	28·94	24·38	30·40
13	3·6055	13·701	11·53	14·42	59	7·6811	29·18	24·57	30·72
14	3·7416	14·22	11·97	14·96	60	7·7459	29·43	24·78	31·00
15	3·8729	14·71	12·39	15·48	61	7·8102	29·67	24·99	31·24
16	4·0000	15·20	12·80	16·00	62	7·8740	29·92	25·19	31·40
17	4·1231	15·66	13·19	16·49	63	7·9372	30·16	25·39	31·74
18	4·2426	16·12	13·57	16·97	64	8·0000	30·40	25·60	32·00
19	4·3588	16·66	13·94	17·43	65	8·0622	30·63	25·79	32·24
20	4·4721	16·99	14·31	17·88	66	8·1240	30·87	25·99	32·60
21	4·5825	17·41	14·66	18·32	67	8·1853	31·10	26·19	32·74
22	4·6904	17·82	15·00	18·75	68	8·2462	31·33	26·38	33·00
23	4·7958	18·22	15·34	19·18	69	8·3066	31·56	26·58	33·22
24	4·8989	18·61	15·67	19·59	70	8·3666	31·79	26·77	33·60
25	5·0000	19·00	16·00	20·00	71	8·4261	32·01	26·96	33·70
26	5·0990	19·37	16·31	20·39	72	8·4852	32·24	27·15	34·00
27	5·1961	19·74	16·62	20·78	73	8·5440	32·46	27·34	34·17
28	5·2915	20·10	16·93	21·16	74	8·6023	32·68	27·52	34·40
29	5·3851	20·46	17·28	21·54	75	8·6602	32·90	27·71	34·64
30	5·4772	20·81	17·52	21·90	76	8·7177	33·12	27·89	35·00
31	5·5677	21·15	17·81	22·26	77	8·7749	33·34	28·07	35·09
32	5·6568	21·49	18·10	22·62	78	8·8317	33·56	28·26	35·20
33	5·7745	21·94	18·47	23·09	79	8·8881	33·77	28·44	35·55
34	5·8309	22·15	18·65	23·32	80	8·9442	33·98	28·62	35·80
35	5·9160	22·48	18·93	23·66	81	9·0000	34·20	28·80	36·00
36	6·0000	22·80	19·20	24·00	82	9·0553	34·41	28·97	36·40
37	6·0827	23·11	19·46	24·32	83	9·1104	34·61	29·15	36·44
38	6·1644	23·42	19·72	24·65	84	9·1651	34·82	29·32	36·80
39	6·2449	23·73	19·98	24·97	85	9·2195	35·03	29·50	36·87
40	6·3245	24·03	20·23	25·29	86	9·2736	35·25	29·67	37·20
41	6·4031	24·33	20·48	25·61	87	9·3273	35·44	29·84	37·30
42	6·4807	24·62	20·73	25·60	88	9·3808	35·64	30·01	37·60
43	6·5574	24·91	20·98	25·22	89	9·4339	35·48	30·18	37·73
44	6·6332	25·20	21·22	26·40	90	9·4868	36·09	30·35	38·00
45	6·7082	25·49	21·46	25·83	91	9·5393	36·24	30·52	38·15
46	6·7823	25·77	21·70	26·80	92	9·5916	36·44	30·69	38·40
47	6·8556	26·05	21·93	27·42	93	9·6436	36·64	30·85	38·57
48	6·9282	26·32	22·17	27·60	94	9·6953	36·84	31·02	38·80
49	7·0000	26·60	22·40	28·00	95	9·7467	37·03	31·18	39·06
50	7·0710	26·86	22·62	28·20	96	9·7979	37·23	31·35	39·20
51	7·1414	27·13	22·85	28·56	97	9·8488	37·42	31·53	39·39
52	7·2111	27·40	23·07	28·80	98	9·8994	37·61	31·67	39·60
53	7·2807	27·66	23·29	29·12	99	9·9498	37·80	31·83	39·79
54	7·3484	27·92	23·51	29·40	100	10·0000	38·00	32·00	40·00
55	7·4161	28·18	23·73	29·66					

TO FIND THE HANK LAP FROM THE COUNTS.

Rule.—*Multiply by the doublings, and divide by the draft at each machine, from the mule or ring frame down to the carding engine, inclusive.*

Suppose you are spinning 48's with a draught at the mule of 8.

Draft at the mule or ring frame 8)48's(6-hank roving.
48

If the draft at the roving frame be 6, making 6-hank roving, what hank will the intermediate be with two ends up?

6-hank roving.
2 ends up or doublings.

6)12(2-hank at intermediate.
12

If the draft at the intermediate frame be 5, making a 2-hank roving, what hank will the slubbing be with two ends up?

2-hank at intermediate.
2 ends up or doublings.

Draft at intermediate 5)4·0(·8-hank slubbing
40

If the draft at the slubbing frame be $4\frac{1}{2}$, making ·8-hank slubbing, what part of a hank will the drawing be at the last head?

Draft at slubbing 4·5)·80(·177-hank at the last head of drawing.
45

350
315

350
315

If the draft at the last head of drawing be 6, making ·177-hank roving, what part of hank will the drawing be at the second head with 6 ends up?

·177-hank at the last head.
6 ends up or doublings.

Draft at last head, 6)1·062(·177-hank at second head.
6
46
42
42
42

If the draft at the second head of drawing be 6, making ·177-hank roving, what part of a hank will the drawing be at the first head with 6 ends up?

·177-hank at the second head.
6 ends up or doublings.

Draft at second head, 6)1·062(·177-hank at first head.
6
46
42
42
42

If the draft at the first head of drawing be $6\frac{1}{4}$, making a ·177-hank roving, what part of a hank will the carding be with 6 ends up?

·177-hank at the first head.
6 ends up or doublings.

Draft at first head, 6·25)1·062(·169-hank carding.
625
4370
3750
6200
5625

If the draft at the carding engine be 121, making ·169-hank carding, what part of a hank will the lap be?

Draft at card, 121)·169(·0014 hank lap.
121
―――
480
484

There is in the processes named about 5 per cent of waste and drying in. The hank lap must therefore be taken 5 per cent coarser to produce the required counts.

·0014
5
―――
100)·0070(·00007
·0070
―――
·00140
·00007
―――
·00133

Ans.—·00133 hank lap.

FOREIGN WEIGHTS, MEASURES, AND MONEYS.

THE METRIC OR FRENCH SYSTEM OF WEIGHTS.

1 Gramme	=	the unit (15·432 grains).
10 Grammes	=	1 decagramme.
100 ,,	=	1 hectogramme.
1000 ,,	=	1 kilogramme.
·1 or $\frac{1}{10}$,,	=	1 decigramme.
·01 or $\frac{1}{100}$,,	=	1 centigramme.
·001 or $\frac{1}{1000}$,,	=	1 milligramme.

LINEAR MEASURES.

1 metre	=	the unit (39·37 inches).
10 metres	=	1 decametre.
100 ,,	=	1 hectometre.
1000 ,,	=	1 kilometre.
·1 or $\frac{1}{10}$,,	=	1 decimetre.
·01 or $\frac{1}{100}$,,	=	1 centimetre.
·001 or $\frac{1}{1000}$,,	=	1 millimetre.

ENGLISH AND FRENCH WEIGHTS.

1	Ton	equals	1016	Kilos.	23	lb.	equals	10·43	Kilos.
19	Cwt.	,,	965·20	,,	22	,,	,,	9·90	,,
17½	,,	,,	889·	,,	21	,,	,,	9·52	,,
15	,,	,,	762·	,,	20	,,	,,	9·07	,,
12½	,,	,,	635·	,,	19	,,	,,	8·61	,,
10	,,	,,	508·	,,	18	,,	,,	8·16	,,
9	,,	,,	457·20	,,	17	,,	,,	7·71	,,
8	,,	,,	406·66	,,	16	,,	,,	7·25	,,
7	,,	,,	355·60	,,	15	,,	,,	6·80	,,
6	,,	,,	304·80	,,	14	,,	,,	6·35	,,
5	,,	,,	254·	,,	13	,,	,,	5·89	,,
4	,,	,,	203·	,,	12	,,	,,	5·44	,,
3	,,	,,	152·40	,,	11	,,	,,	4·98	,,
2	,,	,,	101·60	,,	10	,,	,,	4·53	,,
1	,,	,,	50·80	,,	9	,,	,,	4·08	,,
56	lb.	,,	25·40	,,	8	,,	,,	3·62	,,
42	,,	,,	19·05	,,	7	,,	,,	3·17	,,
34	,,	,,	15·42	,,	6	,,	,,	2·67	,,
28	,,	,,	12·70	,,	5	,,	,,	2·26	,,
27	,,	,,	12·24	,,	4	,,	,,	1·81	,,
26	,,	,,	11·79	,,	3	,,	,,	1·36	,,
25	,,	,,	11·33	,,	2	,,	,,	·83	,,
24	,,	,,	10·88	,,	1	,,	,,	·45	,,

One kilogramme is = 2·2046lb. or 35¼oz. nearly.

Weights, Measures, and Money Values of Countries having commercial relations with the cotton-spinning districts of England:—

CHINA.

1 Leang	or	Tael	=	$\frac{1}{12}$ lb. (Avoir.)				
16 ,,	or	,,	=	$1\frac{1}{3}$,,	,,	=	1 Kire or Cattie.	
1600 ,,	or	,,	=	$133\frac{1}{3}$,,	,,	=	100 ,, or ,,	
						=	1 Tan or Pecul.	

EGYPT.

12 Uckreh or 96 Meticals or 144 Dirhems = 1 Rottolo.
100 Rottolos = 1 Cantar, about 100lb.

INDIA.

1 Seer = 16 Chittacks = 80 Tolas = $2\frac{2}{35}$ lbs. (Avoir).
40 Seers = 1 Maund.

The values of these weights vary very much throughout India.

In Madras the candy = 20 maunds, each of 40 seers. The candy = 493·71lbs. (avoir). By commercial usage the candy is still taken at 500 lbs. and the maund at 25.

In Bombay there is still in use a candy of 20 maunds of 40 seers each = 560 lbs. (avoir).

TURKEY.

1 Kintal or Cantaro = 44 Okes = 100 Rottolos = 124·46 lbs. (Avoir.).
1 Oke = 4 Okiejehs = 400 Dirhems = 2·83 lbs. (Avoir).

MONEY: INDIA.

Taking the Rupee as being worth 16d. sterling, nominal value 2s.,

1 Pice	=	$\frac{1}{12}$d.					
12 ,,	=	1d.	=	1 Anna.			
192 ,,	=	1/4	=	16 ,,	=	1 Rupee.	

£6,666 = 1 Lac = 100,000 Rupees.

CHINA.

Taking the Tael as 4/2 sterling (nominal value 6/6),

$\frac{1}{20}$d.	=	1 Candarine.					
5d.	=	100 ,,	=	1 Mace.			
50d.	=	1000 ,,	=	10 ,,	=	1 Tael.	

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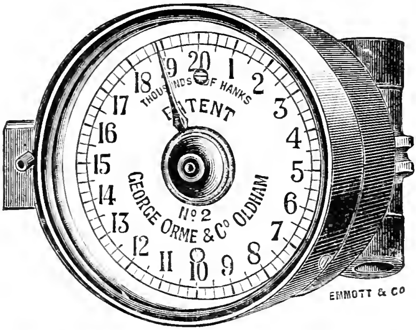

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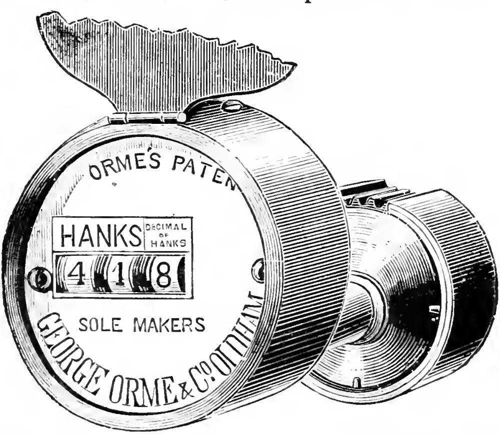

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